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No. 114

HYDROGRAPHIC OFFICE

CONTRIBUTIONS TO TERRESTRIAL MAGNETISM

THE MAGNETIC DIP OR INCLINATION

1897

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The Hydrographic office.

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DEPARTMENT OF THE NAVY
BUREAU OF NAVIGATION

U.S.-Bureau of navigation - HYDROGRAPHIC OFFICE.

CONTRIBUTIONS TO TERRESTRIAL MAGNETISM,

THE MAGNETIC DIP OR INCLINATION.

AS OBSERVED AT THIRTY IMPORTANT MARITIME STATIONS, TOGETHER WITH AN
INVESTIGATION OF THE SECULAR CHANGE IN THE DIRECTION OF A FREELY
SUSPENDED MAGNETIC NEEDLE AT TWENTY-NINE OF THE STATIONS.

BY

G. W. LITTLEHALES,
U. S. Hydrographic Office.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1897.

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The Hydrog. Office

PREFACE.

In this publication Mr. G. W. Littlehales, C. E., of the United States Hydrographic Office, has presented a series of discussions of values of the magnetic dip or inclination, as observed at thirty of the principal maritime stations from early times to the present, together with equations for each station from which values may be predicted and annual rates of change found.

Mr. Littlehales desires to acknowledge the assistance that he has received in the preparation of this work from Mr. M. E. Porter, lately of the United States Hydrographic Office.

To these fresh results Mr. Littlehales has added, from Hydrographic Office publication No. 109a, a résumé of the equations representing the magnetic declination at the same stations, and an investigation and graphical representation of the secular change in the direction of a freely suspended magnetic needle at twenty-nine of the stations.

J. E. Craig,
Commander, U. S. Navy, Hydrographer.

United States Hydrographic Office,
Washington, D. C., July 12, 1897.

CHAPTER I.

The observations that are discussed in this chapter have been collected in the Hydrographic Office, during the period elapsed since 1885, with a view of providing for the deduction of values of the rates of secular change of the magnetic inclination for use in bringing forward from one epoch to another the values of the inclination observed in the regions where the stations are situated, and also for use in shifting the lines of equal magnetic inclination published on charts for past epochs to their positions at the present or some future time. The deduced expressions for the secular change of the magnetic inclination have been used in this manner in connection with the preparation of the Chart of the World, lately published by the Hydrographic Office, showing the lines of equal magnetic dip and variation for the year 1897.

The results as presented also give values of the inclination throughout the range of observation, and for the years 1895, 1900, and 1905, and provide the means for readily deducing the values of the inclination for past years not greatly beyond the range of observation, and also for predicting, within an assigned measure of precision, values for the years up to 1910. To seventeen of the series of observations there has been adapted a periodic function of the form

$$I=A+B_1 \sin \frac{360^\circ}{m} t+B_2 \cos \frac{360^\circ}{m} t,$$

in which I represents the dip or inclination, m the period of the cycle, t the time in years and fractions of a year reckoned from some assumed epoch, and A, B_1 and B_2 constants that are determined from the observations by the method of least squares. And at the remaining thirteen stations a series of powers of the form

$$I=A+B_1 t+B_2 t^2$$

was used. In this manner the rate of movement of the dipping needle is found for any epoch within the range of observation, the times when the needle is stationary are computed, and the values of the inclination are predicted for current use for ten or fifteen years beyond the limits of the period of observation.

Taken in connection with the secular variation expressions of the magnetic declination deduced in Hydrographic Office Publication No. 109a, the expressions for the inclination now presented furnish means for a partial investigation of the secular change in the direction of a freely suspended magnetic needle. This has been undertaken in Chapter II.

Lat. 18° 28′ S. **ARICA, PERU.** Long. 70° 20.5′ W.

Year.	Magnetic dip or inclination.	Authority.	
		Observer.	Where recorded.
	°		
1768......	—28.00	....	Wilcke's Inclination Chart.
1858......	—13.67	Friesach.....................	Phil. Trans. Royal Society, 1877.
1883......	—12.76	Ensign Favereau, Fr. N.....	Annales Hydrographiques, 2d series, 1884.
1893.2....	—11.77	Lieutenant Mottez, Fr. N...	Annales Hydrographiques, 2d vol., 1893.

Year.	Observed.	Computed.	O–C.	$\overline{O-C}^2$.	
	°	°			
1768......	—28.00	—27.99	—0.01	0.0001	Probable error of a single observation = ± 12′. Period = 350 years.
1858......	—13.67	—13.85	+0.18	0.0324	
1883......	—12.76	—12.54	—0.22	0.0484	
1893.2....	—11.77	—11.84	+0.07	0.0049	
				0.0858	

Empirical equation for determining the inclination for any year: $I = -21.67^\circ + 7.02^\circ \sin 1.06\,(t-1850) + 6.89^\circ \cos 1.06\,(t-1850)$.

Lat. 7° 55.5′ S. **ASCENSION, ISLAND.** Long. 14° 24′ W.

Year.	Magnetic dip or inclination.	Authority.	
		Observer.	Where recorded.
	°		
1754....	+11.16	De la Caille..................	Hansteen's Magnetismus der Erde, Christiania, 1819.
1775....	+ 8.95	J. Cook......................	Do.
1822....	+ 5.16	Sabine........................	Becquerel's Traité du Magnétisme, 1846.
1834....	+ 1.95	Allen.........................	Phil. Trans. Royal Society, Part II, 1877.
1836....	+ 1.65	Fitz Roy.....................	Do.
1839....	+ 0.10	Du Petit Thouars...........	Do.
1842....	— 0.13	Allen.........................	Do.
1852.9..	— 4.12	"L'Eugenie"................	Annalen der Hydrographie, 1877.
1863.5..	1863— 4.78	H. M. S. Hecate.............	Phil. Trans. Royal Society, Part II, 1877.
	1864— 5.95	Rokeby.......................	Do.
1876.2..	— 7.75	H. M. S. Challenger.........	Voyage of H. M. S. Challenger.
1890.2..	—11.63	E. D. Preston, assistant, Coast and Geodetic Survey.	Coast and Geodetic Survey Report, 1891.

Year.	Observed.	Computed.	O–C.	$\overline{O-C}^2$.	
	°	°			
1754......	+11.16	+11.10	+0.06	0.0036	Probable error of a single observation = ±44′. Period = 600 years.
1775......	+ 8.95	+10.94	—1.99	3.9601	
1822......	+ 5.16	+ 3.62	+1.54	2.3716	
1834......	+ 1.95	+ 1.33	+0.62	0.3844	
1836......	+ 1.65	+ 0.91	+0.74	0.5476	
1839......	+ 0.10	+ 0.29	—0.19	0.0361	
1842......	— 0.13	— 0.34	+0.21	0.0441	
1852.9....	— 4.12	— 2.76	—1.36	1.8496	
1863.5....	— 5.37	— 5.18	—0.19	0.0361	
1876.2....	— 7.75	— 8.22	+0.47	0.2209	
1890.2....	—11.63	—11.63	0.00	0.0000	
				9.4541	

Empirical equation for determining the inclination for any year: $I = -12.32^\circ - 21.24^\circ \sin 0.6\,(t-1850) + 10.24^\circ \cos 0.6\,(t-1850)$.

Lat. 13° S. **BAHIA, BRAZIL.** Long. 38° 32′ W.

Year.	Magnetic dip or inclination.	Authority.	
		Observer.	Where recorded.
	°		
1822......	+4.20	Sabine........................	Becquerel's Traité du Magnétisme, 1846.
1832......	+4.93	Fitz Roy........................	Phil. Trans. Royal Society, Part II, 1877.
1837......	+5.58	Wickham....................	Do.
1839......	+5.02	Sulivan......................	Do.
1865......	+4.40	Harkness....................	Do.
1873.7....	+4.04	H. M. S. Challenger	Voyage of H. M. S. Challenger.
1881.3....	+2.57	Van Ryckevorsel...........	Magnetic Survey of Eastern part of Brazil, published by Royal Academy of Sciences, Amsterdam, 1890.
1887.7....	+1.57	Lieutenant de Roujon, Fr. N.	Annales Hydrographiques, vol. 3, 1888.
1895.8....	+0.48	Lieutenant Schwerer, Fr. N.	Annales Hydrographiques, 1896.

Year.	Observed.	Computed.	O–C.	$O-C^2$.	
	°	°			
1822......	4.20	4.40	—0.20	0.0400	Probable error of a single observation is ±11′. Period = 360 years.
1832......	4.93	4.99	—0.06	0.0036	
1837......	5.58	5.19	+0.39	0.1529	
1839......	5.02	5.25	—0.23	0.0529	
1865......	4.40	4.51	—0.11	0.0121	
1873.7....	4.04	3.67	+0.37	0.1369	
1881.3....	2.57	2.72	—0.15	0.0225	
1887.7....	1.57	1.78	—0.21	0.0441	
1895.8....	0.48	0.42	+0.06	0.0036	
				0.4686	

Empirical equation for determining the inclination for any year: $I = -7.85^\circ - 1.21^\circ \sin(t-1850) + 13.11^\circ \cos(t-1850)$.

Lat. 13° 05′ N. **BARBADOS (BRIDGETOWN).** Long. 59° 37′ W.

Year.	Magnetic dip or inclination.	Authority.	
		Observer.	Where recorded.
	°		
1722.7....	44. 5	....	Appendix No. 1, Report of United States Coast and Geodetic Survey for 1895, p. 266.
1835.3....	43.76	Home........................	Do.
1836......	43.48		
1846......	43.95	Schomburgh................	Do.
1880......	43.37	H. M. S. Challenger Magnetic Chart.	Report of Scientific Results of the Exploring Voyage of H. M. S. Challenger, 1873–1876, Physics and Chemistry, Vol. II.
1890.3....	43.13	E. D. Preston	Bulletin No. 23, United States Coast and Geodetic Survey, March, 1891.

Year.	Observed.	Computed.	O–C.	$\overline{O-C}^2$.	
	°	°			
1722.7....	44. 5	44.49	+0.01	.0001	Probable error of a single observation = ± 8′.
1835.7....	43.26	43.82	—0.20	.0400	
1846......	43.95	43.70	+0.25	.0625	
1880......	43.37	43.34	+0.03	.0009	
1890.5....	43.13	43.23	—0.10	.0100	
				.1135	

$$I = +43.66 - 0.0108\,(t-1850) - 0.000034\,(t-1850)^2.$$

Lat. 6° 08′ S. **BATAVIA.** Long. 106° 48′ E.

Year.	Magnetic dip or inclination.	Authority.	
		Observer.	Where recorded.
	°		
1768......	—40.00	....	Wiicke's Inclination Chart.
1828......	—25.93	Blosseville.................	Phil. Trans. Royal Society, Part II, 1877.
1846......	—27.08	Elliot......................	Do.
1858......	—27.58	Novara expedition..........	Do.
1876......	—27.63	Van Ryckevorsel...........	Magnetic Survey of the Eastern part of Brazil. Published by the Royal Academy of Sciences, Amsterdam.
1882.7....	—28.07	Observatory...............	Magnetic and Meteorological Observations at the Batavian Observatory.
1883.5....	—27.96	.....do.....................	Do.
1884.5....	—28.05	.....do.....................	Do.
1885.5....	—28.17	.....do.....................	Do.
1886.5....	—28.24	.....do.....................	Do.
1887.5....	—28.35	.....do.....................	Do.
1888.5....	—28.42	.....do.....................	Do.
1889.5....	—28.51	.....do.....................	Do.
1890.5....	—28.72	.....do.....................	Do.
1891.5....	—28.85	.....do.....................	Do.
1892.5....	—28.97	.....do.....................	Do.
1893.5....	—29.10	.....do.....................	Do.
1894.5....	—29.23	.....do.....................	Do.

Year.	Observed.	Computed.	O-C.	$\overline{O-C}^2$.	
	°	°			
1768......	—40.00	—38.97	—1.03	1.0609	Probable error of a single observation = ± 29′. Period = 300 years.
1828......	—25.93	—28.20	+2.27	5.1529	
1846......	—27.08	—26.73	—0.35	0.1225	
1858......	—27.58	—26.48	—1.10	1.2100	
1876......	—27.63	—27.25	—0.38	0.1444	
1882.7....	—28.07	—27.86	—0.21	0.0441	
1883.5....	—27.96	—27.95	—0.01	0.0001	
1884.5....	—28.05	—28.06	+0.01	0.0001	
1885.5....	—28.17	—28.17	—0.00	0.0000	
1886.5....	—28.24	—28.26	+0.02	0.0004	
1887.5....	—28.35	—28.41	+0.06	0.0036	
1888.5....	—28.42	—28.52	+0.10	0.0100	
1889.5....	—28.51	—28.65	+0.14	0.0196	
1890.5....	—28.72	—28.79	+0.07	0.0049	
1891.5....	—28.85	—28.92	+0.07	0.0049	
1892.5....	—28.97	—29.06	+0.09	0.0081	
1893.5....	—29.10	—29.19	+0.09	0.0081	
1894.5....	—29.23	—29.33	+0.10	0.0100	
				7.8046	

Empirical equation for determining the inclination for any year: $I = -36.19^{\circ} + 1.40^{\circ} \sin 1.2\,(t-1850) + 9.61^{\circ} \cos 1.2\,(t-1850)$.

Lat. 18° 56′ N. **BOMBAY.** Long. 72° 54′ E.

Year.	Magnetic dip or inclination.	Authority.	
		Observer.	Where recorded.
	°		
1845	+17.98	Orlebar	Phil. Trans. Royal Society, 1875.
1847	+18.30	Montrion	Do.
1849	+18.87	Cassini	Annales Hydrographiques, 1851.
1856	+19.10	Schlagintweit	Phil. Trans. Royal Society, 1875.
1863	+19.22		Johnson's Encyclopedia.
1867.5	+19.03	Observatory	Phil. Trans. Royal Society, 1875.
1868.5	+19.07	do	Phil. Trans. Royal Society, 1876.
1869.5	+19.10	do	Do.
1870.5	+19.13	do	Do.
1871.5	+19.15	do	Bombay Magnetic and Meteorological Observations.
1872.5	+19.23	do	Do.
1873.5	+19.25	do	Do.
1874.5	+19.25	do	Do.
1875.5	+19.22	do	Do.
1876.5	+19.20	do	Do.
1877.5	+19.33	do	Do.
1878.5	+19.33	do	Do.
1879.5	+19.37	do	Do.
1880.5	+19.37	do	Do.
1881.5	+19.53	do	Do.
1882.5	+19.72	do	Do.
1883.5	+19.72	do	Do.
1884.5	+19.75	do	Do.
1885.5	+19.77	do	Do.
1886.5	+19.77	do	Do.
1887.5	+19.77	do	Do.
1888.5	+20.18	do	Do.
1889.5	+20.27	do	Do.
1890.5	+20.33	do	Do.
1891.5	+20.42	do	Do.
1892.5	+20.50	do	Do.
1893.5	+20.58	do	Do.
1894.5	+20.68	do	Do.

BOMBAY.—Continued.

Year.	Observed.	Computed.	O-C.	$\overline{O-C}^2$.	
	°	°			
1845......	+17.98	+18.39	—0.41	0.1681	Probable error of a single observation = ± 8′. Period = 600 years.
1847......	+18.30	+18.43	—0.13	0.0169	
1849......	+18.87	+18.45	+0.42	0.1764	
1856......	+19.10	+18.59	+0.51	0.2601	
1863......	+19.22	+18.81	+0.41	0.1681	
1867.5....	+19.03	+18.97	+0.06	0.0036	
1868.5....	+19.07	+19.02	+0.05	0.0025	
1869.5....	+19.10	+19.06	+0.04	0.0016	
1870.5....	+19.13	+19.11	+0.02	0.0004	
1871.5....	+19.15	+19.15	+0.00	0.0000	
1872.5....	+19.23	+19.20	+0.03	0.0009	
1873.5....	+19.25	+19.24	+0.01	0.0001	
1874.5....	+19.25	+19.29	—0.04	0.0016	
1875.5....	+19.22	+19.33	—0.11	0.0121	
1876.5....	+19.20	+19.39	—0.19	0.0361	
1877.5....	+19.33	+19.43	—0.10	0.0100	
1878.5....	+19.33	+19.48	—0.15	0.0225	
1879.5....	+19.37	+19.54	—0.17	0.0289	
1880.5....	+19.37	+19.61	—0.24	0.0576	
1881.5....	+19.53	+19.66	—0.13	0.0169	
1882.5....	+19.72	+19.73	—0.01	0.0001	
1883.5...	+19.72	+19.77	—0.05	0.0025	
1884.5....	+19.75	+19.84	—0.09	0.0081	
1885.5....	+19.77	+19.91	—0.14	0.0196	
1886.5....	+19.77	+19.96	—0.19	0.0361	
1887.5....	+19.77	+20.02	—0.25	0.0625	
1888.5....	+20.18	+20.09	+0.09	0.0081	
1889.5....	+20.27	+20.15	+0.12	0.0144	
1890.5....	+20.33	+20.23	+0.10	0.0100	
1891.5....	+20.42	+20.29	+0.13	0.0169	
1892.5....	+20.50	+20.35	+0.15	0.0225	
1893.5....	+20.58	+20.42	+0.16	0.0256	
1894.5....	+20.68	+20.50	+0.18	0.0324	
				1.2432	

Empirical equation for determining the inclination for any year: $I = 30.47° + 1.67° \sin 0.6\,(t-1850) - 12.00° \cos 0.6\,(t-1850)$.

Lat. 12° 04′ S.

CALLAO, PERU.

Long. 77° 08′ W.

Year.	Magnetic dip or inclination.	Authority.	
		Observer.	Where recorded.
	°		
1790......	—12.37	Malaspina....................	Bode's Astronomisches Jahrbuch, 1828.
1823......	— 8.55	Duperrey.....................	Voyages of the Adventure and Beagle, 1826-1836, London, 1839.
1835......	— 7.05	Fitz Roy......................	Do.
1838......	— 6.23	Belcher.......................	Phil. Trans. Royal Society, Part II, 1877.
1838......	— 6.82	"La Venus"................	Do.
1858......	— 7.17	Friesach......................	Do.
1866......	— 6.47	Harkness....................	Do.
1893......	— 5.25	Lieutenant Mottez, Fr. N..	Annales Hydrographiques, 2d vol., 1893.

Year.	Observed.	Computed.	O-C.	$\overline{O-C}^2$.	
	°	°			
1790......	—12.37	—12.17	—0.20	0.0400	Probable error of a single observation = ±31′.
1823......	— 8.55	— 8.34	—0.21	0.0441	
1835......	— 7.05	— 7.37	+0.32	0.1024	
1838......	— 6.23	— 7.16	+0.93	0.8649	
1838......	— 6.82	— 7.16	+0.34	0.1156	
1858......	— 7.17	— 6.12	—1.05	1.1025	
1866......	— 6.47	— 5.86	—0.61	0.3721	
1893......	— 5.25	— 5.75	+0.50	0.2500	
				2.8916	

Empirical equation for determining the inclination for any year: $I = -6.46^\circ + 0.0495^\circ (t - 1850) - 0.00076^\circ (t - 1850)^2$.

Lat. 33° 56′ S.

CAPE OF GOOD HOPE.

Long. 18° 29′ E.

Year.	Magnetic dip or inclination.	Authority.	
		Observer.	Where recorded.
	°		
1751	—43.00		On the Causes of Phenomenon of Terrestrial Magnetism, by Wilde.
1770	—44.37	C. G. Ekeberg	Hansteen's Magnetismus der Erde, Christiania, 1819.
1774	—44.48	do	Do.
1775	—45.32		On the Causes of Phenomenon of Terrestrial Magnetism, by Wilde.
1780	—46.77		Do.
1792	—47.42		Do.
1818	—50.67		Do.
1836	—52.58		Do.
1839	—53.10		Do.
1841.5	—53.15	Observatory	Phil. Trans. Royal Society, 1877.
1842.5	—53.22	do	Do.
1843.5	—53.32	do	Do.
1844.5	—53.60	do	Do.
1845.5	—53.53	do	Do.
1846.5	—53.55	do	Do.
1847.5	—53.68	do	Do.
1848.5	—53.78	do	Do.
1849.5	—53.87	do	Do.
1850.5	—53.97	do	Do.
1851.5	—54.03	do	Do.
1857.0	—54.60	Novara Expedition	Do.
1873.9	—55.93	H. M. S. Challenger	Voyage of H. M. S. Challenger.
1880	—57.00		On the Causes of Phenomenon of Terrestrial Magnetism, by Wilde.
1890.1	—57.25	E. D. Preston, assistant, United States Coast and Geodetic Survey.	Coast and Geodetic Survey Report, 1891.

CAPE OF GOOD HOPE.—Continued.

Year.	Observed.	Computed.	O–C.	$\overline{O-C}^2$.	
	°	°			
1751......	—43.00	—42.93	—0.07	0.0049	Probable error of a single observation = ± 12.6′. Period = 450 years.
1770......	—44.37	—44.77	+0.40	0.1600	
1774......	—44.48	—45.21	+0.73	0.5329	
1775......	—45.32	—45.32	0.00	0.0000	
1780......	—46.77	—45.87	—0.90	0.8100	
1792......	—47.42	—47.28	—0.14	0.0196	
1818......	—50.67	—50.44	—0.23	0.0529	
1836......	—52.58	—52.55	—0.03	0.0009	
1839......	—53.10	—52.87	—0.23	0.0529	
1841.5....	—53.15	—53.16	+0.01	0.0001	
1842.5....	—53.22	—53.26	+0.04	0.0016	
1813.5....	—53.32	—53.37	+0.05	0.0025	
1844.5....	—53.60	—53.47	—0.13	0.0169	
1845.5....	—53.53	—53.58	+0.05	0.0025	
1846.5....	—53.55	—53.69	+0.14	0.0196	
1847.5....	—53.68	—53.79	+0.11	0.0121	
1848.5....	—53.78	—53.89	+0.11	0.0121	
1849.5....	—53.87	—53.99	+0.12	0.0144	
1850.5....	—53.97	—54.09	+0.12	0.0144	
1851.5....	—54.03	—54.19	+0.16	0.0256	
1857.0....	—54.60	—54.73	+0.13	0.0169	
1873.9....	—55.93	—56.13	+0.20	0.0400	
1880......	—57.00	—56.56	—0.44	0.1936	
1890.1....	—57.25	—57.13	—0.12	0.0144	
				2.0229	

Empirical equation for determining the inclination for any year: $I \doteq -49.11^\circ - 7.23^\circ \sin 0.8\,(t-1850) - 4.93^\circ \cos 0.8\,(t-1850)$.

Lat. 19° 26′ N. **CITY OF MEXICO.** Long. 90° 05′ W.

Year.	Magnetic dip or inclination.	Authority.	
		Observer.	Where recorded.
1778......	+38.00	Don Alzate..................	Encyclopedia Metropolitana, 1848.
1799......	+42.17	A. von Humboldt...........	Do.
1856......	+41.43	Müller and Sontag..........	Phil. Tran. Royal Society, 1875.
1858......	+41.44	.....do.........................	Smithsonian Contributions to Knowledge, 1860.
1879.7....	+44.86	V. Reyes.....................	Memoria sobre el Dept. Magnetico, etc., Mexico, 1880.
1884......	+45.02	M. Barcena.................	United States Coast and Geodetic Survey, Report for 1885, Appendix No. 6.
1888......	+45.05	Observatory.................	Mem. del Observatorio Met. Central de México.
1890......	+44.05	.....do.........................	Do.
1895......	+44.37	Observatory.................	Boletín del Observatorio Astronómico Nacional de Tacubaya, Tomo 1, 1896.

Year.	Observed.	Computed.	O–C.	$\overline{O-C}^2$.	
	°	°			
1778......	+38.00	+39.40	−1.40	1.9600	Probable error of a single observation = ± 60′. Period = 300 years.
1799......	+42.17	+39.74	+2.43	5.9049	
1856......	+41.43	+42.66	−1.23	1.5129	
1858......	+41.44	+42.77	−1.33	1.7689	
1879.7....	+44.86	+43.99	+0.87	0.7569	
1884......	+45.02	+44.20	+0.82	0.6724	
1888......	+45.05	+44.38	+0.67	0.4489	
1890......	+44.05	+44.46	−0.41	0.1681	
1895......	+44.37	+44.66	−0.29	0.0841	
				13.2771	

Empirical equation for determining the inclination for any year: $I = 42.32° + 2.92° \sin 1.2\,(t - 1850) - 0.04° \cos 1.2\,(t - 1850)$.

Lat. 36° 42′ S.

CONCEPCION.

Long. 73° 07′ W.

Year.	Magnetic dip or inclination.	Authority.	
		Observer.	Where recorded.
	°		
1710......	−55.50	Feuillée......................	Hansteen's Magnetismus der Erde, Christiania, 1819.
1768......	−55.50	....	Wilcke's Magnetic Chart.
1794......	−52.18	Malaspina...................	Berliner Astronomisches Jahrbuch, 1828.
1823......	−44.70	Duperrey.....................	Phil. Trans. Royal Society, 1877.
1827......	−45.55	Lütke.........................	Do.
1829......	−45.18	King...........................	Do.
1835......	−43.25	Fitz Roy......................	Do.
1882.7....	−37.97	Lieutenants Barnaud and Barnadières, Fr. N.	Annales Hydrographiques, 1884.
1893.2....	−36.67	Lieut. Mottez, Fr. N........	Annales Hydrographiques, Vol. II, 1893.

Year.	Observed.	Computed.	O-C.	$\overline{O-C}^2$	
	°	°			
1710......	−55.50	−56.01	+0.51	0.2601	Probable error of a single observation = ± 38′. Period = 400 years.
1768......	−55.50	−54.73	−0.77	0.5929	
1794......	−52.18	−51.12	−1.06	1.1236	
1823......	−44.70	−46.17	+1.47	2.1609	
1827......	−45.55	−45.49	−0.06	0.0036	
1829......	−45.18	−45.15	−0.03	0.0009	
1835......	−43.25	−44.10	+0.85	0.7225	
1882.7....	−37.97	−37.32	−0.65	0.4225	
1893.2....	−36.67	−36.38	−0.29	0.0841	
				5.3711	

Empirical equation for determining the inclination for any year: $I = -46.42^{\circ} + 10.05^{\circ} \sin 0.9\,(t-1850) + 4.80^{\circ} \cos 0.9\,(t-1850)$.

Lat. 29° 57′ S.

COQUIMBO.

Long. 71° 22′ W.

Year.	Magnetic dip or inclination.	Authority.	
		Observer.	Where recorded.
	°		
1710......	−47.42	Feuillée......................	Hansteen's Magnetismus der Erde, 1819.
1791......	−40.45	Malaspina...................	Berliner Astronomisches Jahrbuch, 1828.
1868......	−29.92	H. M. S. Nassau.............	Phil. Trans. Royal Society, 1877.
1883......	−29.40	Ensign Favereau, Fr. N....	Annales Hydrographiques, 2d. series, 1884.

Year.	Observed.	Computed.	O-C.	$O\text{-}C.^2$	
	°	°	°		
1710......	−47.42	−47.43	+0.01	0.0001	Probable error of a single observation = ±3′. Period = 327 years.
1791......	−40.45	−40.46	+0.01	0.0001	
1868......	−29.92	−29.87	−0.05	0.0025	
1883......	−29.40	−29.45	+0.05	0.0025	
				0.0052	

Empirical equation for determining the inclination for any year: $I = -38.53^{\circ} + 5.51^{\circ} \sin 1.1\,(t-1850) + 7.22^{\circ} \cos 1.1\,(t-1850)$.

Lat. 38° 32′ N. **FAYAL, AZORES.** Long. 28° 33′ W.

Year.	Magnetic dip or inclination.	Authority.	
		Observer.	Where recorded.
	°		
1767*	72.00	C. G. Ekeberg	Hansteen's Magnetismus der Erde, 1819.
1775	71.02	Cook	Coast and Geodetic Survey Report for 1891.
1805.5	67.20	Von Humboldt	Beiträge zur Kenntniss des Wesens der Säcular-Variation des Erdmagnetismus, von L. A. Bauer.
1831.5	68.57	Austin, Foster	Do.
1850	65.88	Rattlesnake	Do.
1873.5	64.95	H. M. S. Challenger	Do.
1880.7	63.64	Thorpe	Do.
1889.8	64.23	E. D. Preston, assistant, United States Coast and Geodetic Survey.	Coast and Geodetic Survey Report for 1891.

Year.	Observed.	Computed.	O-C.	$\overline{O-C}^2$.	
	°	°			
1767*	72.00	70.93	+1.07	1.1449	Probable error of a single observation = ± 47′. Period=450 years.
1775	71.02	70.51	+0.51	0.2601	
1805.5	67.20	68.75	—1.55	2.4025	
1831.5	68.57	67.11	+1.46	2.1316	
1850	65.88	65.93	—0.05	0.0025	
1873.5	64.95	64.69	+0.26	0.0676	
1880.7	63.64	64.35	—0.71	0.5041	
1889.8	64.23	63.96	+0.27	0.0729	
				5.4413	

* Omitted.

Empirical equation for determining the inclination for any year: $I = 67.80^\circ - 4.87^\circ \sin [0.75^\circ (t - 1850) + 22.1^\circ]$.

This equation was deduced by Dr. L. A. Bauer with the above data.

Lat. 23° 09′ N. **HABANA.** Long. 82° 22′ W.

Year.	Magnetic dip or inclination.	Authority.	
		Observer.	Where recorded.
	°		
1801......	+53.37	A. von Humboldt...........	Becquerel's Traité du Magnétisme, 1846.
1822......	+51.92	Sabine.......................	Phil. Trans. Royal Society, Part I, 1875.
1857......	+52.00	Friesach.....................	Do.
1879......	+52.30	Lieut. Commander Ackley, U. S. N.	Report of Coast and Geodetic Survey, 1881.
1885.9....	+52.33	....	Observaciones Magnéticas y Meteorológicas del Real Colegio de Belen, 1876.
1887.3....	+52.17	Lieut. Aubry, Fr. N..........	Annales Hydrographiques, Vol. II, 1888.

Year.	Observed.	Computed.	O-C.	$\overline{O-C}^2$.	
	°	°			
1801......	+53.37	+53.36	+0.01	0.0001	Probable error of a single observation = ± 14′.
1822......	+51.92	+52.35	−0.43	0.1849	
1857......	+52.00	+51.74	+0.26	0.0676	
1879......	+52.30	+52.03	+0.27	0.0729	
1885.9....	+52.33	+52.26	+0.07	0.0049	
1887.3....	+52.17	+52.30	−0.13	0.0169	
				0.3473	

Empirical equation for determining the inclination for any year: $I = 51.76^{\circ} - 0.0058^{\circ}\,(t - 1850) + 0.00055\,(t - 1850)^2$.

Lat. 22° 16′ N. **HONGKONG.** Long. 114° 10′ E.

Year.	Magnetic dip or inclination.	Authority.	
		Observer.	Where recorded.
	°		
1791	+27.92	Malaspina	Bode's Astronomisches Jahrbuch, 1828.
1827	+29.95	Beechey	Phil. Trans. Royal Society, Part I, 1875.
1837	+30.53	Darandeau	Do.
1841.1	+30.05	Observatory	Observations and Researches at the Hongkong Observatory, 1885. (See Appendix A.)
1843	+30.05	Belcher	Phil. Trans. Royal Society, Part I, 1875.
1843.8	+30.83	Observatory	Observations and Researches at the Hongkong Observatory, 1885. (See Appendix A.)
1851	+29.67	Collinson	Phil. Trans. Royal Society, Part I, 1875.
1858	+31.13	Novara Expedition	Do.
1858.1	+31.10	Observatory	Observations and Researches at the Hongkong Observatory, 1885. (See Appendix A.)
1872.3	+32.30	Shadwell	Phil. Trans. Royal Society, Part I, 1877.
1873.3	+32.33	do	Do.
1874.3	+32.29	do	Do.
1875	+32.34	H. M. S. Challenger	Voyage of H. M. S. Challenger.
1875	+32.30	do	Do.
1875.7	+31.95	Fritsche	Ergänzungsheft No. 77 zu Petermann's Mittheilungen, Band XVII, 1884-85.
1884.5	+32.45	Observatory	Observations and Researches at the Hongkong Observatory, W. Doberck, director.
1885.5	+32.44	do	Do.
1886.5	+32.43	do	Do.
1887.5	+32.37	do	Do.
1888.5	+32.35	do	Do.
1889.5	+32.28	do	Do.
1890.2	+32.17	do	Do.
1891.3	+32.40	Lieutenant De Roujon, Fr. N.	Annales Hydrographiques, 2nd series, 1st vol., 1892.
1891.8	+32.08	Observatory	Observations and Researches at the Hongkong Observatory, W. Doberck, director.
1892.5	+32.05	do	Do.
1893.5	+31.95	do	Do.
1894.5	+31.88	do	Do.

HONGKONG—Continued.

Year.	Observed.	Computed.	O–C.	$\overline{O-C}^2$.
	°	°		
1791......	+27.92	+26.99	+0.93	0.8649
1827......	+29.97	+29.89	+0.08	0.0064
1837......	+30.53	+30.18	+0.35	0.1225
1841.1....	+30.05	+30.44	—0.39	0.1521
1843......	+30.05	+30.58	—0.53	0.2809
1843.8....	+30.83	+30.59	+0.24	0.0625
1851......	+29.67	+30.99	—1.32	1.7689
1858......	+31.13	+31.34	—0.21	0.0441
1858.1....	+31.10	+31.35	—0.25	0.0625
1872.3....	+32.30	+31.91	+0.39	0.1521
1873.3....	+32.33	+31.91	+0.42	0.1764
1874.3....	+32.29	+31.98	+0.31	0.0961
1875......	+32.34	+32.00	+0.34	0.1156
1875......	+32.30	+32.00	+0.30	0.0900
1875.7....	+31.95	+32.02	—0.07	0.0049
1884.5....	+32.45	+32.23	+0.22	0.0484
1885.5....	+32.44	+32.26	+0.18	0.0324
1886.5....	+32.43	+32.27	+0.16	0.0256
1887.5....	+32.37	+32.29	+0.08	0.0064
1888.5....	+32.35	+32.31	+0.04	0.0016
1889.5....	+32.28	+32.32	—0.04	0.0016
1890.2....	+32.17	+32.34	—0.17	0.0289
1891.3....	+32.40	+32.35	+0.05	0.0025
1891.8....	+32.08	+32.35	—0.27	0.0729
1892.5....	+32.05	+32.36	—0.31	0.0961
1893.5....	+31.95	+32.37	—0.42	0.1764
1894.5....	+31.88	+32.38	—0.50	0.2500
				4.7427

Probable error of a single observation = ± 18′.
Period = 400 years.

Empirical equation for determining the inclination for any year: $I = 27.82^\circ + 3.38^\circ \sin 0.9\,(t - 1850) + 3.12^\circ \cos 0.9\,(t - 1850)$.

Lat. 21° 18′ N. **HONOLULU.** Long. 157° 52′ W.

Year.	Magnetic dip or inclination.	Authority.	
		Observer.	Where recorded.
	°		
1830......	41.70	Douglas	Phil. Trans. Royal Society, Part I, 1875.
1836......	42.10	"Bonite"......................	Do.
1837......	41.60	Beechey	Do.
1838......	41.30	Belcher	Do.
1852.5....	41.18	Swedish Magnetic Survey..	Annalen der Hydrographie, 1877.
1875.5....	39.78	H. M. S. Challenger	Voyage of H. M. S. Challenger.
1890.6....	40.53	Lieutenant Courmes, Fr. N.	Annales Hydrographiques, 2d vol., 1892.
1892.5....	40.70	E. D. Preston, assistant, United States Coast and Geodetic Survey.	Report of United States Coast and Geodetic Survey, Part II, 1893.

Year.	Observed.	Computed.	O-C.	$\overline{O-C}^2$.	
	°	°			
1830......	+41.70	+42.10	−0.40	0.1600	Probable error of a single observation = ±17′.
1836......	+42.10	+41.65	+0.45	0.2025	
1837......	+41.60	+41.59	+0.01	0.0001	
1838......	+41.30	+41.51	−0.21	0.0441	
1852.5....	+41.18	+40.74	+0.44	0.1936	
1875.5....	+39.78	+40.28	−0.50	0.2500	
1890.6....	+40.53	+40.50	+0.03	0.0009	
1892.5....	+40.70	+40.55	+0.15	0.0225	
				0.8737	

Empirical equation for determining the inclination for any year: $I = 40.31° - 0.0093° (t - 1870) + 0.00089° (t - 1870)^2$.

Lat. 24° 38′ N. **MAGDALENA BAY.** Long. 112° 07′ W

Year.	Magnetic dip or inclination.	Authority.	
		Observer.	Where recorded.
1837......	+50.72	Du Petit and Thouars	Phil. Trans. Royal Society, 1875.
1866.5....	+48.53	Harkness	Smithsonian Contributions to Knowledge, No 239, 1873.
1873.2....	+48.15	W. Eimbeck, assistant, Coast and Geodetic Survey.	Coast and Geodetic Survey, report for 1881.
1881.2....	+48.32	Lieut. Commander H. E. Nichols, U. S. N.	Do.
1895.2....	+48.52	Lieut. F. M. Bostwick, U. S. N.	Hydrographic Office, archive document.

Year.	Observed.	Computed.	O-C.	$\overline{O-C}^2$.	
	°	°			
1837......	+50.72	+50.71	+0.01	0.0001	Probable error of a single observation = + 5′.
1866.5....	+48.53	+48.46	+0.07	0.0049	
1873.2....	+48.15	+48.28	−0.13	0.0169	
1881.2....	+48.32	+48.23	+0.09	0.0081	
1895.2....	+48.52	+48.54	−0.02	0.0004	
				0.0304	

Empirical equation for determining the inclination for any year: $I = 48.26° - 0.0135° (t - 1875) + 0.00135° (t - 1875)^2$.

Lat. 14° 36′ N.

MANILA.

Long. 120° 58′ E.

Year.	Magnetic dip or inclination.	Authority.	
		Observer.	Where recorded.
	°		
1766......	+11.68	Le Gentil....................	Hansteen's Magnetismus der Erde, Christiania, 1819.
1786......	+11.08	"Boussole"	Do.
1792.6....	+10.67	Malaspina....................	Berliner Astronomisches Jahrbuch, 1828.
1829......	+16.27	Lütke	Phil. Trans. Royal Society, 1875.
1836......	+16.50	"Bonite"....................	Do.
1840......	+16.45	....	El Magnetismo Terrestre en Filipinas, 1893.
1844......	+16.43	Belcher........................	Phil. Trans. Royal Society, 1875.
1853......	+15.58	"L'Eugene"	Annalen der Hpdrographie, 1877.
1874......	+17.98	H. M. S. Challenger.........	Voyage of H. M. S. Challenger.
1887.5....	+17.47	Observatory	El Magnetismo Terrestre en Filipinas, 1893.
1889.5....	+17.38	.....do	Do.
1890.5....	+17.37	.....do	Do.
1891.5....	+17.27	.....do	Do.
1891.9....	+17.23	H. M. S. Penguin	Phil. Trans. Royal Society, 1896, A.
1892.5....	+17.18	Observatory.................	El Magnetismo Terrestre en Filipinas, 1893.

Year.	Observed.	Computed.	O-C.	$\overline{O-C}^2$.	
	°	°			
1766......	+11.68	+10.19	+1.49	2.2201	Probable error of a single observation = ± 35′. Period = 360 years.
1786......	+11.08	+11.83	—0.75	0.5625	
1792.6....	+10.67	+12.40	—1.73	2.9929	
1829......	+16.27	+15.35	+0.92	0.8464	
1836......	+16.50	+15.82	+0.68	0.4624	
1840......	+16.45	+16.06	+0.39	0.1521	
1844......	+16.43	+16.29	+0.14	0.0196	
1853......	+15.58	+16.75	—1.17	1.3689	
1874......	+17.98	+17.37	+0.61	0.3721	
1887.5....	+17.47	+17.42	+0.05	0.0025	
1889.5....	+17.38	+17.40	—0.02	0.0004	
1890.5....	+17.37	+17.39	—0.02	0.0004	
1891.5....	+17.27	+17.39	—0.12	0.0144	
1891.9....	+17.23	+17.38	—0.15	0.0225	
1892.5....	+17.18	+17.37	—0.19	0.0361	
				9.0733	

Empirical equation for determining the inclination for any year: $I = 12.49^\circ + 2.74^\circ \sin (t - 1850) + 4.11^\circ \cos (t - 1850)$.

Lat. 34° 54′ S. **MONTEVIDEO.** Long. 56° 12′ W.

Year.	Magnetic dip or inclination.	Authority.	
		Observer.	Where recorded.
	°		
1790......	—42. 22	Malaspina..................	Berliner Astronomisches Jahrbuch, 1828.
1827......	—36. 47	King........................	Phil. Trans. Royal Society, Part II, 1877.
1833......	—34. 85	Fitz Roy.....................	Do.
1836......	—34. 83	"Bonite".....................	Do.
1838......	—34. 05	Sulivan.......................	Do.
1852......	—32. 12	Macrae	Do.
1866......	—31. 10	Harkness.....................	Do.
1867......	—31. 03	H. M. S. Nassau..............	Do.
1876. 2....	—29. 81	H. M. S. Challenger..........	Voyage of H. M. S. Challenger.
1882. 7....	—29. 33	Lieutenants Barnaud and Barnardières, Fr. N.	Annales Hydrographiques, 1884.
1893. 4....	—28. 13	Lieutenant Mottez, Fr. N ...	Annales Hydrographiques, Vol. II, 1893.
1895. 9....	—28. 30	Lieutenant Schwerer, Fr. N .	Annales Hydrographiques, 1896.

Year.	Observed.	Computed.	O-C.	$\overline{\text{O-C}}^2$.	
	°	°			
1790......	—42. 22	—42. 22	+0. 00	0. 0000	Probable error of a single observation = ±12′.
1827......	—36. 47	—35. 94	—0. 53	0. 2809	
1833......	—34. 85	—35. 06	+0. 21	0. 0441	
1836......	—34. 83	—34. 64	—0. 19	0. 0361	
1838......	—34. 05	—34. 36	+0. 31	0. 0961	
1852......	—32. 12	—32. 53	+0. 41	0. 1681	
1866......	—31. 10	—30. 92	—0. 18	0. 0324	
1867......	—31. 03	—30. 82	—0. 21	0. 0441	
1876. 2....	—29. 81	—29. 88	+0. 07	0. 0049	
1882. 7....	—29. 33	—29. 27	—0. 06	0. 0036	
1893. 4....	—28. 13	—28. 38	+0. 25	0. 0625	
1895. 9....	—28. 30	—28. 14	—0. 16	0. 0256	
				0. 7984	

Empirical equation for determining the inclination for any year: $I = -32.78^\circ + 0.125^\circ\ (t-1850) - 0.00054^\circ\ (t-1850)^2$.

Lat. 5° 05′ S. **PAITA, PERU.** Long. 81° 05.5′ W.

Year.	Magnetic dip or inclination.	Authority.	
		Observer.	Where recorded.
	°		
1823......	+4.02	4.11 Duperrey	Becquerel's Traité du Megnétisme, 1846.
		3.93 Duperrey	Phil. Trans. Royal Society, 1877.
1832......	+4.67	Boussingault	Do.
1836......	+4.42	"Bonite".....................	Do.
1838......	+4.53	"La Venus"	Do.
1866......	+4.97	Harkness....................	Do.
1893.9....	+6.07	Lieutenant Mottez, Fr. N..	Annales Hydrographiques, vol. 1, 1893.

Year.	Observed.	Computed.	O–C.	$\overline{O-C}^2$.	
	°	°			
1823......	+4.02	+4.22	–0.20	0.0400	Probable error of a single observation = ± 14′.
1832......	+4.67	+4.38	+0.29	0.0841	
1836......	+4.42	+4.45	–0.03	0.0009	
1838......	+4.53	+4.50	+0.03	0.0009	
1866......	+4.97	+5.14	–0.17	0.0289	
1893.9....	+6.07	+5.99	+0.08	0.0064	
				0.1612	

Empirical equation for determining the inclination for any year: $I = 4.75° + 0.0231° (t - 1850) + 0.000119° (t - 1850)^2$.

Lat. 8° 57′ N. **PANAMA.** Long. 79° 32′ W.

Year.	Magnetic dip or inclination.	Authority.	
		Observer.	Where recorded.
	°		
1790......	+29.48	Malaspina..................	Bode's Astronomisches Jahrbuch, 1828.
1837......	+31.87	E. Belcher..................	Phil. Trans. Royal Society, 1843.
1849......	+32.00	Emory.......................	Phil. Trans. Royal Society, Part I, 1875.
1858......	+32.50	R. W. Haig.................	Phil. Trans. Royal Society, 1864.
1866......	+31.93	Harkness....................	Smithsonian Contributions to Knowledge, No. 239, 1873.
1891.4....	+31.32	Lieutenant Courmes, Fr. N.	Annales Hydrographiques, 1892.

Year.	Observed.	Computed.	O–C.	$\overline{O-C}^2$.	
	°	°			
1790......	+29.48	+29.43	+0.05	0.0025	Probable error of a single observation = ±6′.
1837......	+31.87	+31.90	–0.03	0.0009	
1849......	+32.00	+32.08	–0.08	0.0064	
1858......	+32.50	+32.11	+0.22	0.0484	
1866......	+31.93	+32.04	–0.11	0.0121	
1891.4 ...	+31.32	+31.34	–0.02	0.0004	
				0.0707	

Empirical equation for determining the inclination for any year: $I = 32.09° + 0.0071° (t - 1850) - 0.00061° (t - 1850)^2$.

PERNAMBUCO.

Lat. 8° 03′ S. Long. 34° 52′ W.

Year.	Magnetic dip or inclination.	Authority.	
		Observer.	Where recorded.
	°		
1768......	+10.00	....	Wilcke's Inclination Chart.
1836......	+13.22	Fitz Roy......................	Phil. Trans. Royal Society, Part II, 1877.
1839......	+13.15	Sulivan.......................	Do.
1865......	+12.13	Harkness....................	Do.
1881.5....	+ 8.95	Van Ryckevorsel	Magnetic Survey of Eastern Part of Brazil, published by Royal Academy of Sciences, Amsterdam, 1890.
1896......	+ 8.00	....	Annales Hydrographiques, 1896.

Year.	Observed.	Computed.	O–C	$\overline{\text{O. C}}^2$.	
	°	°			
1768......	+10.00	+ 9.66	+0.34	0.1156	Probable error of a single observation = ±25′. Period = 360 years.
1836......	+13.22	+13.37	–0.15	0.0225	
1839......	+13.15	+13.26	–0.11	0.0121	
1865......	+12.13	+11.49	+0.64	0.4096	
1881.5....	+ 8.95	+ 9.66	–0.71	0.5041	
1896......	+ 8.00	+ 7.76	+0.24	0.0576	
				1.1215	

Empirical equation for determining the inclination for any year: $I = 5.27° - 3.70°$ sin $(t - 1850) + 7.42°$ cos $(t - 1850)$.

PETROPAVLOVSK.

Lat. 53° 01′ N. Long. 158° 43′ E.

Year.	Magnetic dip or inclination.	Authority.	
		Observer.	Where recorded.
	°		
1779.7....	+63.08	J. King......................	Voyage to the Pacific, 1784.
1804.7....	+63.53	A. J. von Krusenstern.....	Coast and Geodetic Survey Report for 1885. Appendix No. 6.
1827.6....	+64.03	F. W. Beechey..............	Voyage to the Pacific, 1825–28; London, 1831.
1827.8....	+64.12	F. P. Lütke..................	Mémoires, St. Petersburg Acad., 1838.
1829.8....	+63.82	Ad. Erman	Reise um die Erde, Berlin, 1835.
1837.7....	+64.08	Du Petit Thouars...........	Voyage autour du Monde, Paris, 1843.
1854.6....	+64.78	....	Frigate Aurora.
1876.5....	+64.23	M. L. Onazevich............	Magnetic Observations obtained in 1890 in the East Siberian Sea provinces by E. Schtelling.
1890......	+64.48	E. Schtelling................	Do.

Year.	Observed.	Computed.	O–C.	$\overline{\text{O–C}}^2$.	
	°	°			
1779.7....	+63.08	+63.17	–0.09	0.0081	Probable error of a single observation = ±10′. Period = 360 years.
1804.7....	+63.53	+63.59	–0.06	0.0036	
1827.6....	+64.03	+63.97	+0.06	0.0036	
1827.8....	+64.12	+63.98	+0.14	0.0196	
1829.8....	+63.82	+64.00	–0.18	0.0324	
1837.7....	+64.08	+64.12	–0.04	0.0016	
1854.6....	+64.78	+64.33	+0.45	0.2025	
1876.5....	+64.23	+64.49	–0.26	0.0676	
1890.0....	+64.48	+64.53	–0.05	0.0025	
				0.3415	

Empirical equation for determining the inclination for any year: $I = 63.54° + 0.66°$ sin $(t - 1850) + 0.74°$ cos $(t - 1850)$.

Lat. 53° 10′ S.

PUNTA ARENAS.

Long. 70° 54′ W.

Year.	Magnetic dip or inclination.	Authority.	
		Observer.	Where recorded.
	°		
1760......	—65.00		
1769......	—68.85		
1852......	—57.42	"L'Eugenie"...............	Annalen der Hydrographie, 1877.
1866......	—54.95	Harkness....................	Smithsonian Contributions to Knowledge, 1873.
1876......	—53.06	H. M. S. Challenger.........	Voyage of H. M. S. Challenger.
1883......	—52.77	Brazilian Transit of Venus Commission.	Ann. de l'Obs. Imp. de Rio de Janeiro.
1893.3....	—51.33	Lieutenant Mottez, Fr. N..	Annales Hydrographiques, 2d vol., 1893.

Year.	Observed.	Computed.	O-C.	$\overline{O-C}^2$.	
	°	°			
1760......	—65.00	—66.87	+1.87	3.4969	Probable error of a single observation = ±59′. Period = 400 years.
1769......	—68.85	—66.77	—2.08	4.3264	
1852......	—57.42	—57.56	+0.14	0.0196	
1866......	—54.95	—55.22	+0.27	0.0729	
1876......	—53.06	—53.58	+0.52	0.2704	
1883......	—52.77	—52.47	—0.30	0.0900	
1893.3....	—51.33	—50.91	—0.42	0.1764	
				8.4526	

Empirical equation for determining the inclination for any year: $I = -56.23^\circ + 10.51^\circ \sin 0.9^\circ (t - 1850) - 1.66^\circ \cos 0.9^\circ (t - 1850)$.

Lat. 22° 54′ S. **RIO DE JANEIRO.** Long. 43° 10′ W.

Year.	Magnetic dip or inclination.	Authority.	
		Observer.	Where recorded.
	°		
1817......	—14.70	Freycinet...............	Becquerel's Traité du Magnétisme, 1846.
1820......	—14.72	.....do..................	Do.
1821......	—15.43	Rumker................	Do.
1826......	—14.07	King....................	Phil. Trans. Royal Society, 1877.
1827......	—14.58	Lütke..................	Do.
1830......	—13.58	Erman..................	Do.
1832......	—13.62	Fitz Roy..............	Do.
1836......	—12.90	Beechey...............	Do.
1837......	—13.32	Du Petit Thouars......	Do.
1838......	—13.40 { 13.00	Sulivan................	Do.
	13.02	.....do..................	Do.
	13.93	.....do..................	Do.
	13.62	.....do..................	Do.
1839......	—13.12 { 13.08	.....do..................	Do.
	13.16	.....do..................	Do.
1847......	—12.28	"Rattlesnake".........	Do.
1852......	—12.62	"L'Eugenia"...........	Swedish Magnetic Survey.
1857......	—11.80	Novara Ex..............	Phil. Trans. Royal Society, 1877.
1866......	—11.78	Harkness...............	Do.
1881......	—12.13	Van Ryckevorsel.......	Magnetic Survey of Eastern Part of Brazil.
1882.7....	—12.00	Lieutenants Barnaud and Barnadières, Fr. N.	Annales Hydrographiques, 1884.
1887.8....	—11.58	Lieutenant Roujon, Fr. N.	Annales Hydrographiques, 1888.
1896......	—12.92	Lieutenant Schwerer, Fr. N.	Annales Hydrographiques, 1896.

Year.	Observed.	Computed.	O–C.	$\overline{O-C}^2$.	
	°	°			
1817......	—14.70	—15.30	+0.60	0.3600	Probable error of a single observation = ±14′.
1820......	—14.72	—14.89	+0.17	0.0289	
1821......	—15.43	—14.87	—0.56	0.3136	
1826......	—14.07	—14.21	+0.14	0.0196	
1827......	—14.58	—14.10	—0.48	0.2304	
1830......	—13.58	—13.79	+0.21	0.0441	
1832......	—13.62	—13.59	—0.03	0.0009	
1836......	—12.90	—13.24	+0.34	0.1156	
1837......	—13.32	—13.15	—0.17	0.0289	
1838......	—13.40	—13.07	—0.33	0.1089	
1839......	—13.12	—12.99	—0.13	0.0169	
1847......	—12.28	—12.46	+0.18	0.0324	
1852......	—12.62	—12.20	—0.42	0.1764	
1857......	—11.80	—12.01	+0.21	0.0441	
1866......	—11.78	—11.83	+0.05	0.0025	
1881......	—12.13	—11.97	—0.16	0.0256	
1882.7....	—12.00	—12.02	+0.02	0.0004	
1887.8....	—11.58	—12.23	+0.65	0.4225	
1896......	—12.92	—12.68	—0.24	0.0576	
				2.0293	

Empirical equation for determining the inclination for any year: $I = -11.81^\circ - 0.0009^\circ\,(t-1870) - 0.00126^\circ\,(t-1870)^2$.

Lat. 31° 15′ N. **SHANGHAI.** Long. 121° 29′ E.

Year.	Magnetic dip or inclination.	Authority.	
		Observer.	Where recorded.
	°		
1843......	+44.75	Sir E. Home................	Report for 1876 of the Zi-Ka-Wei Observatory.
1858......	+45.35	Novara expedition..........	Phil. Trans. Royal Society, Part I, 1875.
1872.3....	+46.24	Shadwell	Phil. Trans. Royal Society, Part I, 1877.
1873.3....	+46.32	.....do	Do.
1875.5....	+46.26	Jesuit missionaries.........	Le Magnétisme Terrestre à Zi-Ka-Wei, Chine, par Marc Dechevrens, S. J., Directeur de l'Observatoire.
1876.5....	+46.23	.....do	Do.
1877.5....	+46.23	.....do	Do.
1878.5....	+46.22	.....do	Do.
1879.5....	+46.25	.....do	Do.
1880.5....	+46.27	.....do	Do.
1881.5....	+46.28	.....do	Do.
1882.5....	+46.30	.....do	Do.
1883.5....	+46.30	.....do	Do.
1884.5....	+46.32	.....do	Do.
1885.5....	+46.30	.....do	Do.
1886.5....	+46.28	.....do	Do.
1887.5....	+46.27	.....do	Do.
1888.5....	+46.23	.....do	Do.
1889.5....	+46.25	.....do	Do.
1890.5....	+46.19	.....do	Do.
1891.5....	+46.10	.....do	Do.
1892.5....	+46.12	.....do	Do.
1893.5....	+45.99	.....do	Do.
1894.5....	+46.01	.....do	Do.

Year.	Observed.	Computed.	O–C.	$\overline{O-C}^2$.	
	°	°			
1843......	+44.75	+44.63	+0.12	0.0144	Probable error of a single observation = ±2′.
1858......	+45.35	+45.67	—0.32	0.1024	
1872.3....	+46.24	+46.18	+0.06	0.0036	
1873.3....	+46.32	+46.20	+0.12	0.0144	
1875.5....	+46.26	+46.24	+0.02	0.0004	
1876.5....	+46.23	+46.24	—0.01	0.0001	
1877.5....	+46.23	+46.26	—0.03	0.0009	
1878.5....	+46.22	+46.26	—0.04	0.0016	
1879.5....	+46.25	+46.27	—0.02	0.0004	
1880.5....	+46.27	+46.27	+0.00	0.0000	
1881.5....	+46.28	+46.27	+0.01	0.0001	
1882.5....	+46.30	+46.27	+0.03	0.0009	
1883.5....	+46.30	+46.27	+0.03	0.0009	
1884.5....	+46.32	+46.25	+0.07	0.0049	
1885.5....	+46.30	+46.25	+0.05	0.0025	
1886.5....	+46.28	+46.24	+0.04	0.0016	
1887.5....	+46.27	+46.23	+0.04	0.0016	
1888.5....	+46.23	+46.21	+0.02	0.0004	
1889.5....	+46.25	+46.19	+0.06	0.0036	
1890.5....	+46.19	+46.17	+0.02	0.0004	
1891.5....	+46.10	+46.15	—0.05	0.0025	
1892.5....	+46.12	+46.12	+0.00	0.0000	
1893.5....	+45.99	+46.10	—0.11	0.0121	
1894.5....	+46.01	+46.07	—0.06	0.0036	
				0.0733	

Empirical equation for determining the inclination for any year: $I = 46.13^\circ + 0.0251^\circ (t - 1870) - 0.00112^\circ (t - 1870)^2$.

SINGAPORE.

Lat. 1° 18′ N. Long. 103° 51′ E.

Year.	Magnetic dip or inclination.	Authority.	
		Observer.	Where recorded.
	°		
1837......	−12.48	"Bonite"...................	Phil. Trans. Royal Society, 1875.
1841......	−12.72	Capt. C. M. Elliot...........	Magnetic Observations at Singapore.
1842......	−12.70	......do	Do.
1843......	−12.68	......do	Do.
1844......	−12.65	......do	Do.
1845.2....	−12.70	......do	Do.
1846......	−12.92	......do	Phil. Trans. Royal Society, 1875.
1848......	−12.97	......do	Magnetic Observations at Singapore.
1853......	−13.20	"L'Eugenie"...............	Annalen der Hydrographie, 1877.
1874.2....	−13.25	Shadwell	Phil. Trans. Royal Society, 1877.
1875.1....	−13.33	......do	Do.
1876......	−13.11	Van Ryckevorsel...........	Trans. Royal Academy of Sciences, Amsterdam, 1880.
1890.5....	−14.45	"Dubourdieu".............	Letter from British Hydrographer, dated December 13, 1896.

Year.	Observed.	Computed.	O-C.	$\overline{O-C}^2$.	
	°	°			
1837......	−12.48	−12.74	+0.26	0.0676	Probable error of a single observation = ± 9′.
1841......	−12.72	−12.73	+0.01	0.0001	
1842......	−12.70	−12.73	+0.03	0.0009	
1843......	−12.68	−12.73	+0.05	0.0025	
1844......	−12.65	−12.73	+0.08	0.0064	
1845......	−12.70	−12.74	+0.04	0.0016	
1846......	−12.92	−12.75	−0.17	0.0289	
1848......	−12.97	−12.76	−0.21	0.0441	
1853......	−13.20	−12.82	−0.38	0.1444	
1874.2....	−13.25	−13.40	+0.15	0.0225	
1875.1....	−13.33	−13.43	+0.10	0.0100	
1876......	−13.11	−13.47	+0.36	0.1296	
1890.5....	−14.45	−14.19	−0.26	0.0676	
				0.5261	

Empirical equation for determining the inclination for any year: $I = -12.78^\circ - 0.0111^\circ (t-1850) - 0.000587^\circ (t-1850)^2$.

Lat. 15° 55′ S. **ST. HELENA.** Long. 5° 44′ W.

Year.	Magnetic dip or inclination.	Authority.	
		Observer.	Where recorded.
	°		
1754......	— 9.00	De la Caillé..................	Hansteen's Magnetismus der Erde, 1819.
1771......	—13.00	C. G. Ekeberg..............	Do.
1825......	—15.00	—15.05 Duperrey........... —14.94.......................	Becquerel's Traité du Magnétisme, 1846. On the Causes of Phenomenon of Terrestrial Magnetism, by Wilde.
1835......	—18 00	....	Do.
1840......	—21.25	Observatory.................	Phil. Trans. Royal Society, 1877.
1841......	—21.43	.....do.......................	Do.
1842......	—21.42	.....do.......................	Do.
1843......	—21.75	.....do.......................	Do.
1844......	—21.93	.....do.......................	Do.
1845......	—21.92	.....do.......................	Do.
1846......	—22.23	.....do.......................	Do.
1847......	—22.62	.....do.......................	Do.
1848......	—22.82	.....do.......................	Do.
1890.1....	—31.18	E. D. Preston, assistant, United States Coast and Geodetic Survey.	Coast and Geodetic Survey Report for 1891.

Year.	Observed.	Computed.	O-C.	$\overline{O-C}^2$.	
	°	°	°		
1754......	— 9.00	—10.17	+1.17	1.3689	Probable error of a single observation = ±53′. Period = 600 years.
1771......	—13.00	—10.90	—2.10	4.4100	
1825......	—15.00	—17.60	+2.60	6.7600	
1835......	—18.00	—19.46	+1.46	2.1316	
1840......	—21.25	—20.44	—0.81	0.6561	
1841......	—21.43	—20.65	—0.78	0.6084	
1842......	—21.42	—20.85	—0.57	0.3249	
1843......	—21.75	—21.06	—0.69	0.4761	
1844......	—21.93	—21.26	—0.67	0.4489	
1845......	—21.92	—21.47	—0.45	0.2025	
1846......	—22.23	—21.67	—0.56	0.3136	
1847......	—22.62	—21.90	—0.72	0.5184	
1848......	—22.82	—22.12	—0.70	0.4900	
1890.1....	—31.18	—31.34	+0.16	0.0256	
				18.7350	

Empirical equation for determining the inclination for any year: $I = -32.95^\circ - 20.37^\circ \sin 0.6\,(t-1850) + 10.43^\circ \cos 0.6\,(t-1850)$.

Lat. 33° 52′ S. **SYDNEY.** Long. 151° 12′ E.

Year.	Magnetic dip or inclination.	Authority.	
		Observer.	Where recorded.
	°		
1793.2....	—60.01	Malaspina....................	Bode's Astronomisches Jahrbuch, 1828.
1824......	—62.31	Duperrey....................	Phil. Trans. Royal Society, Part II, 1877.
		°	
1831......	—62.86	—62.88, Bethane, 1831.......	Do.
		—62.85, Dunlop, 1831........	Do.
1837......	—62.82	—62.82, Fitz Roy, 1836.......	Do.
		—62.80, Anonymous, 1837....	Do.
		—62.85, Wickham, 1838......	Do.
1841......	—62.84	—62.98, H. M. S. Terror, 1841.	Do.
		—62.80, H. M. S. Erebus, 1841	Do.
		—62.87, H. M. S. Terror, 1841.	Do.
		—62.70, H. M. S. Erebus, 1841	Do.
1844......	—62.63	—62.62, H. M. S. Fly, 1842....	Do.
		—62.75, H. M. S. Fly, 1844....	Do.
		—62.52, H. M. S. Fly, 1845....	Do.
1849......	—62.73	H. M. S. Rattlesnake........	Do.
1852......	—62.73	Kerr........................	Do.
1858......	—62.68	Novara Expedition..........	Do.
1865......	—62.66	Observatory................	Letter dated July 6, 1896, from H. C. Russell, esq., B. A., Government Astronomer, Sydney Observatory.
1874.4....	—62.76	H. M. S. Challenger.........	Voyage of H. M. S. Challenger.
1890.8....	—62.97	Lieutenant Courmes, Fr. N.	Annales Hydrographiques, 2d series, 2d vol., 1892.
1892......	—62.68	Observatory................	Letter dated July 6, 1896, from H. C. Russell, esq., B. A., Government Astronomer, Sydney Observatory.
1896......	—62.70	......do......................	Do.

Year.	Observed.	Computed.	O-C.	$O-C^2$.	
	°	°			
1793.2....	—60.01	—60.17	+0.16	0.0256	
1824......	—62.31	—62.11	—0.20	0.0400	Probable error of a single observation = ±11′.
1831......	—62.86	—62.40	—0.46	0.2116	
1837......	—62.82	—62.61	—0.21	0.0441	
1841......	—62.84	—62.72	—0.12	0.0144	
1844......	—62.63	—62.79	+0.16	0.0256	
1849......	—62.73	—62.90	+0.17	0.0289	
1852......	—62.73	—62.94	+0.21	0.0441	
1858......	—62.68	—63.00	+0.32	0.1024	
1865......	—62.66	—63.02	+0.36	0.1296	
1874.4....	—62.76	—62.98	+0.22	0.0484	
1890.8....	—62.97	—62.64	—0.33	0.1089	
1892......	—62.68	—62.62	—0.06	0.0036	
1896......	—62.70	—62.49	—0.21	0.0484	
				0.8756	

Empirical equation for determining the inclination for any year: $I = -62.97^\circ - 0.0165\,(t-1850) + 0.00056^\circ\,(t-1850)^2$.

Lat. 17° 31′ S. **TAHITI.** Long. 149° 34′ W.

Year.		Magnetic dip or inclination.		Authority.	
				Observer.	Where recorded.
		°			
1769..	1774.	−30.72	30.05	Cook	Hansteen's Magnetismus der Erde, Christiania, 1819.
1773.6		−29.72		Bayley	Walker's Terrestrial and Cosmical Magnetism.
1774.4		−29.97		.....do	Do.
1777.9		−29.78		.....do	Do.
1823	1826...	−30.07	29.92	Duperrey	Phil. Trans. Royal Society, Part II, 1877.
1824		−29.27		Kotzebue	Do.
1830		−30.43		Erman	Do.
1835	1837...	−30.23	29.83	Fitz Roy	Do.
1837		−29.12		Anonymous	Do.
1840		−30.17		Belcher	Do.
1859........		−29.08		Friesach .... Novara Expedition...	Do.
1875.8......		−29.97		H. M. S. Challenger...	Voyage of H. M. S. Challenger.
1890.7......		−29.33		Lieut. Courmes, Fr. N.	Annales Hydrographiques, 2d vol., 1892.

Year.	Observed.	Computed.	O–C.	$\overline{\text{O–C}}^2$	
1774......	−30.05	−29.71	−0.34	0.1156	Probable error of a single observation = ±20′.
1826......	−29.92	−29.70	−0.22	0.0484	
1837......	−29.83	−29.70	−0.13	0.0169	
1859......	−29.08	−29.70	+0.62	0.3844	
1875.8....	−29.97	−29.70	−0.27	0.0729	
1890.7....	−29.33	−29.69	+0.36	0.1296	
				0.7678	

Empirical equation for determining the inclination for any year: $I = -29.70° + 0.00017° (t - 1850)$.

Lat. 33° 02′ S. **VALPARAISO.** Long. 71° 39′ W.

Year.	Magnetic dip or inclination.	Authority.	
		Observer.	Where recorded.
	°		
1790......	—44.96	Malaspina..................	Bode's Astronomisches Jahrbuch, 1828.
1827......	—39.10	Lütke......................	Phil. Trans. Royal Society, Part II, 1877.
1830......	—40.19	King.......................	Do.
1835......	—38.05	Fitz Roy...................	Do.
1836......	—37.08	Beechey....................	Do.
1837......	—38.33	"La Venus".................	Do.
1838......	—38.72	.....do....................	Do.
1838......	—38.20	.....do....................	Do.
1852......	—36.80	Swedish Magnetic Survey..	Annalen der Hydrographie, 1877.
1859......	—35.67	Novara Expedition..........	Phil. Trans. Royal Society, Part II, 1877.
1866......	—35.38	Harkness...................	Do.
1868......	—34.38	H. M. S. Nassau............	Do.
1875.9....	—33.79	H. M. S. Challenger.........	Voyage of H. M. S. Challenger.
1875.9....	—32.57	.....do....................	Do.
1893......	—31.83	Lieutenant Mottez, Fr. N..	Annales Hydrographiques, 2d vol., 1893.

Year.	Observed.	Computed.	O-C.	$\overline{O-C}^2$.	
	°	°	°		
1790......	—44.96	—44.76	—0.20	0.0400	Probable error of a single observation = ± 28′. Period = 400 years.
1827......	—39.10	—39.73	+0.63	0.3969	
1830......	—40.19	—39.31	—0.88	0.7744	
1835......	—38.05	—38.60	+0.55	0.3025	
1836......	—37.08	—38.45	+1.37	1.8769	
1837......	—38.33	—38.32	—0.01	0.0001	
1838......	—38.72	—38.17	—0.55	0.3025	
1838......	—38.20	—38.17	—0.03	0.0009	
1852......	—36.80	—36.32	—0.48	0.2304	
1859......	—35.67	—35.40	—0.27	0.0729	
1866......	—35.38	—34.56	—0.82	0.6724	
1868......	—34.38	—34.33	—0.05	0.0025	
1875.9....	—33.79	—33.49	—0.30	0.0900	
1875.9....	—32.57	—33.49	+0.92	0.8464	
1893......	—31.83	—32.04	+0.21	0.0441	
				5.6529	

Empirical equation for determining the inclination for any year: $I = -39.99^\circ + 8.41^\circ \sin 0.9\,(t-1850) + 3.45^\circ \cos 0.9\,(t-1850)$.

Serial number.	Station.	Latitude.			Longitude.			Equation for inclination for any year A. D.
		°	′		°	′		
1	Arica	18	28	S.	70	20.5	W.	$I=-21.67^\circ+7.02^\circ \sin 1.06\,(t-1850)+6^\circ.89 \cos 1.06\,(t-1850)$.
2	Ascension Island	7	55.5	S.	14	24	W.	$I=-12.32^\circ-21.24^\circ \sin 0.6\,(t-1850)+10.24 \cos 0.6\,(t-1850)$.
3	Bahia	13	00	S.	38	32	W.	$I=-7.85^\circ-1.21^\circ \sin\,(t-1850)+13^\circ.11 \cos\,(t-1850)$.
3a	Barbados	13	05	N.	59	37	W.	$I=+43.66^\circ-0.0108\,(t-1850)-0.000034\,(t-1850)^2$.
4	Batavia	6	08	S.	106	48	E.	$I=-36.19^\circ+1.40^\circ \sin 1.2\,(t-1850)+9^\circ.61 \cos 1.2\,(t-1850)$.
5	Bombay	18	05.6	N.	72	54	E.	$I=+30.47^\circ+1.67^\circ \sin 0.6\,(t-1850)-12.00^\circ \cos 0.6\,(t-1850)$.
6	Callao	12	04	S.	77	08	W.	$I=-6.46^\circ+0.0495^\circ\,(t-1850)-0.00076\,(t-1850)^2$.
7	Cape of Good Hope	33	56	S.	18	29	E.	$I=-49.11^\circ-7.23^\circ \sin 0.8\,(t-1850)-4.93^\circ \cos 0.8\,(t-1850)$.
8	City of Mexico	19	26	N.	99	05	W.	$I=-42.32^\circ+2.92^\circ \sin 1.2\,(t-1850)-0.04^\circ \cos 1.2\,(t-1850)$.
9	Concepcion	36	42	S.	73	07	W.	$I=-46.42^\circ+10.05^\circ \sin 0.9\,(t-1850)+4.80^\circ \cos 0.9\,(t-1850)$.
10	Coquimbo	29	57	S.	71	22	W.	$I=-38.53^\circ+5.51^\circ \sin 1.1\,(t-1850)+7.22 \cos 1.1\,(t-1850)$.
11	Fayal, Azores	38	32	N.	28	33	W.	$I=+67.80^\circ-4.51^\circ \sin 0.75\,(t-1850)-1.83 \cos 0.75\,(t-1850)$.
12	Habana	23	09	N.	82	22	W.	$I=+51.76^\circ-0.0058^\circ\,(t-1850)+0.00055^\circ\,(t-1850)^2$.
13	Hongkong	22	16	N.	114	10	E.	$I=27.82^\circ+3.38^\circ \sin 0.9\,(t-1850)+3.12^\circ \cos 0.9\,(t-1850)$.
14	Honolulu	21	18	N.	157	52	W.	$I=40.31^\circ-0.0033^\circ\,(t-1870)+0.00089^\circ\,(t-1870)^2$.
15	Magdalena Bay	24	38	N.	112	07	W.	$I=48.26^\circ-0.0135^\circ\,(t-1875)+0.00135\,(t-1875)^2$.
16	Manila	14	36	N.	120	58	E.	$I=12.49^\circ+2.74^\circ \sin\,(t-1850)+4.11^\circ \cos\,(t-1850)$.
17	Montevideo	34	54	S.	56	12	W.	$I=-32.78^\circ+0.125^\circ\,(t-1850)-0.00054^\circ\,(t-1850)^2$.
18	Paita	5	05	S.	81	05.5	W.	$I=4.75^\circ+0.023^\circ\,(t-1850)+0.000119^\circ\,(t-1850)^2$.
19	Panama	8	57	N.	79	32	W.	$I=32.09^\circ+0.0071\,(t-1850)-0.00061^\circ\,(t-1850)^2$.
20	Pernambuco	8	03	S.	34	52	W.	$I=5.27^\circ-3.70^\circ \sin\,(t-1850)+7.42^\circ \cos\,(t-1850)$.
21	Petropavlovsk	53	01	N.	158	43	E.	$I=63.54^\circ+0.66^\circ \sin\,(t-1850)+0.74^\circ \cos\,(t-1850)$.
22	Punta Arenas	53	10	S.	70	54	W.	$I=-56.23^\circ+10.51^\circ \sin 0.9\,(t-1850)-1.66 \cos 0.9\,(t-1850)$.
23	Rio de Janeiro	22	54	S.	43	10	W.	$I=-11^\circ.81-0.0009^\circ\,(t-1870)-0.00126^\circ\,(t-1870)^2$.
24	St. Helena	15	55	S.	5	44	W.	$I=-32.95^\circ-20.37^\circ \sin 0.6\,(t-1850)+10.43^\circ \cos 0.6\,(t-1850)$.
25	Shanghai	31	15	N.	121	29	E.	$I=46.13^\circ+0.0251^\circ\,(t-1870)-0.00112^\circ\,(t-1870)^2$.
26	Singapore	1	18	N.	103	51	E.	$I=-12.78^\circ-0.0111^\circ\,(t-1850)-0.000587\,(t-1850)^2$.
27	Sydney	33	52	S.	151	12	E.	$I=-62.97^\circ-0.0165^\circ\,(t-1850)+0.00056^\circ\,(t-1850)^2$.
28	Tahiti	17	31	S.	149	34	W.	$I=-29.70^\circ+0.00017^\circ\,(t-1850)$.
29	Valparaiso	33	02	S.	71	39	W.	$I=-39.99^\circ+8.41^\circ \sin 0.9\,(t-1850)+3.45^\circ \cos 0.9\,(t-1850)$.

Maximum.		Minimum.		Probable error of a single observation.	Inclination.			Annual change.		
N.	S.	N.	S.		1895.	1900.	1905.	1895.	1900.	1905.
				′	°	°	°	′	′	′
....	1718	....	1893	±12	—11.84	—11.91	—12.08	— 0.4	— 1.4	— 2.4
1743	2043	....	....	±44	—12.84	—14.07	—15.31	—15.0	—15.0	—15.0
1844	2024	....	....	±11	+ 0.57	— 0.35	— 1.31	—10.6	—11.4	—12.0
....	....	....	....	± 8	+43.17	+43·12	+43.07	— 0.6	— 0.6	— 0.6
....	2007	....	1857	±29	—29.41	—30.18	—31.00	— 8.7	— 9.6	—10.3
2137	....	1837	....	± 8	+20.54	+20.91	+21.31	+ 4.4	+ 4.7	+ 5.0
....	....	....	....	±31	— 5.76	— 5.89	— 6.04	— 1.1	— 1.6	— 2.0
....	1920	....	1695	±13	—57.35	—57.54	—57.67	— 2.5	— 2.0	— 1.5
1926	....	1776	....	±60	+44.66	+44.83	+44.97	+ 2.2	+ 1.8	+ 1.5
....	1722	....	1922	±38	—36.25	—35.92	—35.66	+ 4.3	+ 3.5	+ 2.7
....	2047	....	1884	± 3	—29.65	—29.88	—30.19	— 2.2	— 3.2	— 4.1
1715	....	1940	....	±47	+63.77	+63.60	+63.45	— 2.1	— 1.9	— 1.7
....	....	....	....	±14	+52.61	+52.84	+53.11	+ 2.5	+ 2.9	+ 3.3
1902	....	1702	....	±18	+32.38	+32.42	+32.41	+ 0.5	+ 0.2	— 0.2
....	....	....	....	±17	+41.69	+42.06	+42.49	+ 4.2	+ 4.8	+ 5.3
....	....	....	....	± 5	+48.53	+48.76	+49.08	+ 1.8	+ 3.2	+ 4.1
1884	....	1704	....	±35	+17.34	+17.23	+17.09	— 1.0	— 1.4	— 1.8
....	....	....	....	±12	—28.24	—27.88	—27.54	+ 4.6	+ 4.3	+ 3.9
....	....	....	....	±14	+ 6.03	+ 6.21	+ 6.38	+ 2.0	+ 2.1	+ 2.2
....	....	....	....	± 6	+31.17	+30.92	+30.64	— 2.9	— 3.2	— 3.6
1824	....	2004	....	±25	+ 7.90	+ 7.21	+ 6.50	— 8.2	— 8.4	— 8.6
1892	....	1712	....	±10	+64.53	+64.52	+64.50	— 0.1	— 0.2	— 0.2
....	1760	....	1960	±59	—50.67	—49.97	—49.32	+ 8.6	+ 8.2	+ 7.6
....	....	....	....	±14	—12.62	—12.97	—13.38	— 3.8	— 4.6	— 5.3
....	2045	....	1745	±53	—32.91	—34.10	—35.30	—13.7	—13.7	—13.7
....	....	....	....	± 2	+46.05	+45.87	+45.64	— 1.9	— 2.5	— 3.2
....	....	....	....	± 9	—14.47	—14.80	—15.16	— 3.8	— 4.2	— 4.5
....	....	....	....	±11	—62.54	—62.33	—62.13	+ 2.0	+ 2.2	+ 2.7
....	....	....	....	±20	—29.69	—29.69	—29.69	0.0	0.0	0.0
....	1720	....	1920	±28	—31.91	—31.60	—31.36	+ 3.9	+ 3.3	+ 2.7

CHAPTER II.

THE SECULAR CHANGE IN THE DIRECTION OF THE MAGNETIC NEEDLE.

A freely suspended magnetic needle is observed to be in a state of continuous tremulous motion of an involved character which may be resolved into irregular and periodic. The irregular motions comprise those sudden and rapid fluctuations in the direction of the needle which can not be predicted. The periodic motions are the solar variations which include the solar-diurnal variation depending upon the hour of the day, the annual variation depending upon the day of the year, and the solar-synodic variation depending upon the synodic revolution of the sun, the lunar variations depending upon the moon's hour-angle and her other elements of position, and partaking of the character of the tides, and the decennial variations which may depend upon the frequency and magnitude of the solar spots. Both the irregular and periodic motions referred to are of such small amplitude in all except the polar regions of the earth that they do not affect any of the practical uses of the magnetic needle on the sea; but besides these there is another motion, having an amplitude reaching 30° or 40° in some parts of the world, which is also supposed to be of periodic character, and which is doubtless of radical importance in meteorological science and in the use of the compass in modern navigation.

At a particular instant of time the lines of magnetic force at any place, to which a freely suspended magnetic needle will set itself tangent, will have a certain direction and strength. The angle between the plane of the astronomical meridian and the vertical plane passing through the needle, or the line of force, is the magnetic declination, or the variation of the compass; the angle between the horizon and the direction of the needle, measured in the vertical plane passing through it, is the dip, or inclination; and the force with which the needle is held in the direction of the lines of force is called the magnetic intensity. The declination and inclination, or the directional elements, which alone are concerned in a discussion of the motion of the magnetic needle, have generally been treated separately in investigating the secular change of the magnetic needle. From 1634, when the fact of the secular variation of the declination was established, and from 1676, when the inclination or dip was discovered, reliable observations of these respective elements are recorded for the great populous centers of Europe, and soon observations of the declination or variation of the compass, a knowledge of which is necessary to mariners in the navigation of their ships, had been made by navigators in most of the known parts of the world. Although the older observations, having been made without the means of precise measurement, are subject to a probable error of as much as 1°, they can be accepted as serviceable in the discussion of long series, and serve to reveal satisfactorily the secular change of the declination. Through the results of the observations of the navigators of successive periods, series of observations of the declination extending over two or three centuries are available for most of the important maritime stations of the world. On platting the observations at a given station with reference to rectangular coordinates, using values of the declination as ordinates and intervals of time as abscissas, sinuous curves are developed which suggest the periodic character of the secular variation, and it is now customary to adapt to the series of observations for their discussion a periodic function of the form

$$v=A+B_1 \sin \frac{360^\circ}{m} t + B_2 \cos \frac{360^\circ}{m} t,$$

in which v represents the variation, m the period of the cycle, t the time in years and fractions of a year reckoned from some assumed epoch, and A, B_1 and B_2 constants to be determined from the observations.

In this manner the rate of movement of the compass needle is found for any epoch within the range of observation, the times when the needle is stationary are computed, and the values of the declination are predicted for current use for ten or fifteen years beyond the limits of observation, within an assigned measure of precision. An examination of the curves resulting from platting the observed and computed values of the declination at a few stations, where the series extend over the greatest duration and are the most complete, will show upon what evidence rests the widespread belief that the secular variation of the magnectic declination is a periodic phenomenon.

There are also available for discussion, by means of the harmonic equation above stated, or by means of a series of powers, series of observations of the dip or magnetic inclination ranging from one hundred to three hundred years in duration, but the stations are not so numerous nor the observations so complete as in the case of the declination, except in the long-settled regions of European civilization. This is accounted for by the fact that the dip was rarely observed by navigators, except when employed in expeditions of scientific research, while the declination was found as a necessary performance in the navigation of their ships. The investigation of the longer series has led to the belief that the secular variaton of the inclination is also a periodic phenomenon; but the data which have been observed up to the present are manifestly insufficient to warrant a conclusion that after a certain period has elapsed the declination at any given station will be the same as it is now, and will then repeat its changes and again assume the same value after the lapse of the same interval of time, or that the inclination at that place will be found to pass through a cycle of changes and return to the same value at regular intervals of time. While the separate investigation of series of observations of declination and inclination is of great practical usefulness in gaining a knowledge of the rate of secular change of these elements and predicting values beyond the range of the observations, in seeking to discover the causes of the secular change in the direction of the magnetic needle, and to establish or disprove its periodic character, the declination and inclination should be viewed as component effects of the forces that are acting. Such a view brings us to the investigation of the successive directions in space assumed at successive epochs by a freely suspended magnetic needle or the consideration of the observed values of the declination and inclination conjointly, instead of the separate consideration of values of the direction of the compass needle and of the dipping needle. As a freely suspended magnetic needle assumes its successive directions for different times, it describes a conical surface whose vertex is the center of gravity of the needle.

If a sphere of any convenient radius be described, with its center coinciding with the center of gravity of the needle, and the conical surface be extended through the surface of the sphere, the line of intersection will be a serpentine curve, whose geometrical nature should be fully investigated, since it represents the actual secular motion of the needle.

At the present time we know, with moderate accuracy, the values of the three magnetic elements for the inhabited portions of the world, and also, with a lesser accuracy, the rates of secular change in the elements, but we have no knowledge as to whether the needle, when it points in a certain direction at a given place, will ever return to the same position again, or whether it will at the end of a certain period assume the same direction, and again sweep over the same path in the same period. Nor do we know that the secular-variation period, if there shall hereafter be found to be one, will be the same in all parts of the world.

To secure to mariners the benefits of increased knowledge and better data for the management of the compass in modern navigation, by promoting the study of the secular change and by providing for the prediction of the magnetic declination and inclination conjointly, values of the declination, at intervals of ten years, have been computed from the empirical equations deduced in Hydrographic Office publication No. 109a, of which a résumé is given in Table No. 1, and values of the inclination, for the same years, have been computed from the empirical equations deduced in the foregoing part of this publication, of which a résumé is given in Table No. 2. The coordinate values of the declination and inclination thus computed are given in Table No. 3. These values for each station have been platted upon a gnomonic or central projection tangent to a sphere whose radius is 12 inches, in latitude and longitude corresponding to the mean dip and declination at the station.

TABLE NO. 1.—*Secular variation expressions of the magnetic declination.* (*a*)

Station.	Latitude.	Longitude from Greenwich.	Empirical expression D =	Epoch.	Probable error of a single observation.	Period assumed.
	° ′	° ′	° ° ° °		′	
Aden	12 47 N.	44 59 E.	$9.20 + 5.89 \times \sin(\frac{9}{11}\tau + 224.0)$	1612–1887	± 43.0	440
Arica, Peru	18 28 S.	70 20.5 W.	$-9.40 + 1.46 \sin(1.5\tau + 278.8)$	1713–1893	06.0	240
Ascension Island	7 55.5 S.	14 24 W.	$10.55 + 13.45 \sin(0.6\tau + 45.3)$	1700–1890	22.6	600
Auckland, New Zealand.	36 50 S.	174 49 E.	$-14.36 + 0.46 \sin(1.1\tau + 30.6)$	1848–1891	10.0	327
Batavia, Java	6 08 S.	106 48 E.	$1.50 + 3.16 \sin(0.9\tau + 247.8)$	1605–1885	15.0	400
Bombay	18 56 N.	72 54 E.	$2.66 + 3.49 \sin(0.8\tau + 242.2)$	1722–1889	12.0	450
Bridgetown	13 05 N.	59 37 W.	$-1.54 + 2.74 \sin(1.2\tau + 17.2)$	1726–1893	15.0	300
Buenos Ayres	34 36 S.	58 22 W.	$-12.03 + 3.50 \sin(1.0\tau + 10.05)$	1829–1883	38.9	360
Cartagena	10 25 N.	75 32 W.	$-5.81 + 2.08 \sin(1.2\tau + 22.5)$	1705–1888	15.8	300
Callao	12 04 S.	77 08 W.	$-8.45 + 2.16 \sin(1.2\tau + 267.2)$	1709–1893	12.2	300
Cape of Good Hope	33 56 S.	18 29 E.	$14.63 + 15.00 \sin(0.61\tau + 77.8)$	1605–1890	22.5	590
Charlottetown, Prince Edward Island.	46 14 N.	63 08 W.	$15.15 + 7.96 \sin(\frac{18}{19}\tau + 77.6)$	1842–1886	20.0	380
City of Mexico	19 26 N.	99 05 W.	$-5.52 + 3.09 \sin(1.0\tau + 270.5)$	1769–1885	18.0	360
Concepcion	36 42 S.	73 07 W.	$-13.63 + 3.52 \sin(1.0\tau + 256.6)$	1709–1893	23.2	360
Coquimbo	29 57 S.	71 22 W.	$-11.55 + 2.83 \sin(1.0\tau + 264.3)$	1700–1891	21.0	360
Curaçao	12 07 N.	68 57 W.	$-4.91 + 2.82 \sin(1.0\tau + 23.1)$	1704–1894	13.7	360
Fayal, Azores	38 32 N.	28 33 W.	$11.82 + 14.75 \sin(\frac{36}{53}\tau + 89.1)$	1590–1891	46.0	530
Fort de France	14 36 N.	61 04 W.	$-2.73 + 3.30 \sin(\frac{12}{11}\tau + 27.6)$	1682–1887	19.0	330
Galapagos Islands.	1 00 S.	90 00 W.	$-7.49 + 1.91 \sin(1.5\tau + 272.1)$	1794–1880	25.0	240
Halifax, Nova Scotia.	44 39.6 N.	63 35.3 W.	$16.74 + 4.30 \sin(\frac{36}{35}\tau + 39.5)$	1700–1879	26.0	350
Habana	23 09 N.	82 22 W.	$-3.42 + 3.14 \sin(1.0\tau + 318.75)$	1726–1889	17.0	360
Honolulu	21 18 N.	157 52 W.	$-9.52 + 0.0158(\tau) - 0.00074(\tau)^2$	....	....	....
Hongkong	22 16 N.	114 10 E.	$-0.99 + 2.08 \sin(0.8\tau + 280.8)$	1780–1887	15.0	450
La Guaira	10 36 N.	66 56.5 W.	$-3.58 + 1.61 \sin(1.0\tau + 357.7)$	1800–1890	21.0	360
Lagoon Head, Mexico.	28 15 . N.	114 06 W.	$-9.85 + 1.99 \sin(\frac{10}{7}\tau + 229.7)$	1783–1888	09.0	252
Magdalena Bay	24 38 N.	112 07 W.	$-7.48 + 3.11 \sin(\frac{10}{7}\tau + 241.8)$	1783–1881	35.0	252
Manila, Luzon Island.	14 36 N.	120 58 E.	$-0.22 + 0.58 \sin(1.0\tau + 226.3)$	1766–1890	08.3	360
Montevideo	34 54 S.	56 12 W.	$-10.28 + 3.90 \sin(1.0\tau + 358.3)$	1790–1894	12.3	360
Nagasaki	32 43 N.	129 51 E.	$2.74 + 0.0237(\tau) + 0.0000774(\tau)^2$	1805–1892	05.1	....
Nosy Vé	23 39 S.	43 36 E.	$15.31 + 8.30 \sin(0.6\tau + 146.1)$	1607–1890	30.0	600
Paita, Peru	5 05 S.	81 05.5 W.	$-7.42 + 1.76 \sin(1.2\tau + 288.4)$	1821–1894	14.2	300
Panama	8 57 N.	79 32 W.	$-6.54 + 1.37 \sin(1.8\tau + 4.4)$	1776–1885	13.0	200
Pekin	39 54 N.	116 28 E.	$2.179 + 0.0131(\tau) - 0.000117(\tau)^2$	1755–1887	06.0	....
Pernambuco	8 03 S.	34 52 W.	$8.99 + 9.46 \sin(0.9\tau + 356.7)$	1815–1894	17.4	400
Petropavlovsk	53 01 N.	158 43 E.	$-2.68 + 3.35 \sin(\frac{10}{7}\tau + 0.3)$	1779–1891	21.3	252
Puna and Guayaquil.	2 45 2 13 S.	79 52 W.	$-8.46 + 0.02(\tau) + 0.0001(\tau)^2$..	1791–1880	10.0	....
Punta Arenas	53 10 S.	70 54 W.	$-18.68 + 5.12 \sin(1.0\tau + 301.9)$	1766–1893	16.6	360
Rio de Janeiro	22 54 S.	43 10 W.	$1.81 + 8.86 \sin(1.0\tau + 348.1)$	1768–1888	25.0	360
St. Johns, New Foundland.	47 34 N.	52 41 W.	$15.63 + 15.52 \sin(1.0\tau + 72.0)$	1845–1885	17.4	360
San Blas, Mexico	21 32 N.	105 19 W.	$-6.60 + 2.82 \sin(\frac{10}{7}\tau + 258.6)$	1783–1880	26.0	252
St. Helena	15 55 S.	5 44 W.	$7.90 + 15.92 \sin(0.6\tau + 68.2)$	1610–1890	41.8	600
St. Vincent	16 53 N.	24 59 W.	$10.48 + 10.22 \sin(0.6\tau + 45.2)$	1615–1894	25.0	600
San Diego, Cal	32 43 N.	117 10.3 W.	$-11.85 + 1.33 \sin(1.5\tau + 214.6)$	1783–1889	11.0	240
Shanghai	31 15 N.	121 29 E.	$1.91 - 0.000012(\tau) + 0.000149(\tau)^2$	1858–1884	1.6	....
Singapore	1 18 N.	103 51 E.	$0.24 + 2.70 \sin(0.9\tau + 244.1)$	1824–1891	17.0	400

a. *West* declination is *plus*, *east* declination is *minus*; τ stands for date—1850.

Table No. 1.—*Secular variation expressions of the magnetic declination* (*a*)—Continued.

Station.	Latitude.	Longitude from Greenwich.	Empirical expression D =	Epoch.	Probable error of a single observation.	Period assumed.
	° ′	° ′	° ° ° °		′	
Sydney	33 52 S.	151 12 E.	$-8.12 + 1.61 \sin(\tfrac{1}{8}^{\circ}\tau + 258.4)$	1770–1880	10 .4	320
Surabaya	7 14 S.	112 45 E.	$2.74 + 4.70 \sin(0.9\tau + 234.6)$	1793–1876	06 .4	400
Tahiti, Society Islands.	17 31 S.	149 34 W.	$-5.64 + 1.95 \sin(1.0\tau + 244.9)$	1768–1878	14 .0	360
Vera Cruz	19 12 N.	96 08 W.	$-4.77 + 3.91 \sin(1.0\tau + 279.0)$	1726–1889	29 .0	360
Valparaiso	33 02 S.	71 39 W.	$-12.64 + 3.12 \sin(1.0\tau + 270.8)$	1709–1884	18 .0	360

a. West declination is *plus*, *east* declination is *minus*; τ stands for date—1850.

Table No. 2.—*Secular variation expressions of the magnetic inclination.* (*a*)

Station.	Latitude.	Longitude from Greenwich.	Empirical expression I =	Epoch.	Probable error of a single observation.	Period assumed.
	° ′	° ′	° ° ° °		′	
Arica	18 28 S.	70 20.5 W.	$-21.67 + 9.84 \sin(1.06\tau + 44.5)$	1768 –1893.2	±12	350
Ascension Island	7 55.5 S.	14 24 W.	$-12.32 + 23.58 \sin(0.6\tau + 154.3)$	1754 –1890.2	44	600
Bahia	13 00 S.	38 32 W.	$-7.85 + 13.17 \sin(1.0\tau + 95.3)$	1822 –1895.8	11	360
Bridgetown	13 05 N.	59 37 W.	$+43.66 - 0.0108(\tau) - 0.000034(\tau)^2$	1722¾ –1890.5	8	....
Batavia	6 08 S.	106 48 E.	$-36.19 + 9.71 \sin(1.2\tau + 81.7)$	1768 –1894.5	29	300
Bombay	18 56 N.	72 54 E.	$+30.47 + 12.12 \sin(0.6\tau + 277.9)$	1845 –1894.5	8	600
Callao	12 04 S.	77 08 W.	$-6.46 + 0.0495(\tau) - 0.00076(\tau)^2$	1790 –1893	31	....
Cape of Good Hope	33 56 S.	18 29 E.	$-49.11 + 8.75 \sin(0.8\tau) + 214.3)$	1751 –1890.1	12 .6	450
City of Mexico	19 26 N.	99 05 W.	$+42.32 + 2.92 \sin(1.2\tau) + 359.2)$	1778 –1895	60	300
Concepcion	36 42 S.	73 07 W.	$-46.42 + 11.12 \sin(0.9\tau) + 25.5)$	1710 –1893.2	38	400
Coquimbo	29 57 S.	71 22 W.	$-38.53 + 9.08 \sin(1.1\tau) + 52.6)$	1710 –1883	3	327
Fayal, Azores	38 32 N.	28 33 W.	$+67.80 + 4.87 \sin(0.75\tau) + 202.1)$	1775 –1889.8	47	450
Habana	23 09 N.	82 22 W.	$+51.76 - 0.0058(\tau) + 0.00055(\tau)^2$	1801 –1887.3	14	....
Hongkong	22 16 N.	114 10 E.	$+27.82 + 4.60 \sin(0.9\tau + 42.7)$	1791 –1894.5	18	400
Honolulu *b*	21 18 N.	157 52 W.	$+40.31 - 0.0093(\tau) + 0.00089(\tau)^2$	1830 –1892.5	17	....
Magdalena Bay *c*	24 38 N.	112 07 W.	$+48.26 - 0.0135(\tau) + 0.00135(\tau)^2$	1837 –1895.2	5	....
Manila	14 36 N.	120 58 E.	$+12.49 + 4.94 \sin(1.0\tau + 56.3)$	1766 –1892.5	35	360
Montevideo	34 54 S.	56 12 W.	$-32.78 + 0.125(\tau) - 0.00054(\tau)^2$	1790 –1895.9	12	....
Paita	5 05 S.	81 05.5 W.	$+4.75 + 0.023(\tau) + 0.000119(\tau)^2$	1823 –1893.9	14	....
Panama	8 57 N.	79 32 W.	$+32.09 + 0.0071(\tau) - 0.00061(\tau)^2$	1790 –1891.4	6	....
Pernambuco	8 03 S.	34 52 W.	$+5.27 + 8.29 \sin(1.0\tau + 116.5)$	1768 –1896	25	360
Petropavlovsk	53 01 N.	158 43 E.	$+63.54 + 0.99 \sin(1.0\tau + 48.3)$	1779.7–1890	10	360
Punta Arenas	53 10 S.	70 54 W.	$-56.23 + 10.64 \sin(0.9\tau + 351.0)$	1760 –1893.3	59	400
Rio de Janeiro *b*	22 54 S.	43 10 W.	$-11.81 - 0.0009(\tau) - 0.00126(\tau)^2$	1817 –1896	14	....
St. Helena	15 55 S.	5 44 W.	$-32.95 + 22.88 \sin(0.6\tau - 152.9)$	1754 –1890.1	53	600
Shanghai *b*	31 15 N.	121 29 E.	$+46.13 + 0.0251(\tau) - 0.00112(\tau)^2$	1843 –1894.5	2 .4	....
Singapore	1 18 N.	103 51 E.	$-12.78 - 0.0111(\tau) - 0.000587(\tau)^2$	1837 –1890.5	9	....
Sydney	33 52 S.	151 12 E.	$-62.97 - 0.0165(\tau) + 0.00056(\tau)$	1793.2–1896	11	....
Tahiti	17 31 S.	149 34 W.	$-29.70 + 0.00017(\tau)$	1769 –1890.7	20	....
Valparaiso	33 02 S.	71 39 W.	$-39.99 + 9.09 \sin(0.9\tau + 22.3)$	1790 –1893	±28	400

a Inclination of *north* end *below* the horizon is *positive*, *above* the horizon is *negative*; τ expresses the interval of time reckoned from 1850, plus when forward and minus when backward.

b N. B.—In this case, τ is reckoned from 1870 instead of 1850.

c N. B.—In this case, τ is reckoned from 1875 instead of 1850.

TABLE NO. 3.

Station.	1750.		1760.		1770.	
	D.	I.	D.	I.	D.	I.
	°	°	°	°	°	°
Arica	— 8.26		— 8.54		— 8.87	—28.04
Ascension Island	+ 7.13	+11.19	+ 8.52	+10.88	+ 9.92	+10.32
Barbados (Bridgetown) *a*	— 4.22	+44.30	— 4.28	+44.35	— 4.22	+44.30
Batavia	+ 2.69		+ 2.22	—40.49	+ 1.73	—38.59
Bombay	+ 3.73		+ 3.25		+ 2.77	
Callao						
Cape of Good Hope	+18.96	—42.84	+20.46	—43.75	+21.90	—44.78
City of Mexico			— 5.55		— 6.08	+39.42
Concepcion	—12.23	—56.46	—12.81	—55.58	—13.42	—54.48
Coquimbo	—10.78	—46.18	—11.27	—45.10	—11.76	—43.79
Fayal, Azores	+17.13		+18.72		+20.21	+70.79
Habana	— 5.39		— 5.78		— 6.10	
Honolulu						
Hongkong						
Magdalena Bay						
Manila			+ 0.18	+09.75	+ 0.10	+10.50
Montevideo						
Paita						
Panama					— 7.43	
Pernambuco				+ 8.95		+10.18
Petropavlovsk					— 5.74	+63.02
Punta Arenas			—21.38	—66.87	—22.10	—66.74
Rio de Janeiro			— 6.86		— 7.04	
St. Helena	+10.18	—10.09	+11.80	—10.34	+13.39	—10.85
Shanghai						
Singapore						
Sydney						
Tahiti			— 4.81	—29.72	— 5.13	—29.71
Valparaiso						

Station.	1720.		1730.		1740.	
	D.	I.	D.	I.	D.	I.
	°	°	°	°	°	°
a Barbados (Bridgetown)	— 3.35	+44.49	— 3.74	+44.47	— 4.03	+44.44

Station.	1780.		1790.		1800.	
	D.	I.	D.	I.	D.	I.
	°	°	°	°	°	°
Arica	— 9.24	—26.54	— 9.62	—24.89	— 9.99	—23.13
Ascension Island	+11.33	+ 9.49	+12.73	+ 8.43	+14.10	+ 7.16
Barbados (Bridgetown)	— 4.06	+44.25	— 3.78	+44.19	— 3.40	+44.12
Batavia	+ 1.23	—36.58	+ 0.74	—34.56	+ 0.27	—32.60
Bombay	+ 2.28		+ 1.80		+ 1.31	
Callao			— 9.01	—12.17	— 9.44	—10.83
Cape of Good Hope	+23.25	—45.88	+24.51	—47.04	+25.66	—48.24
City of Mexico	— 6.60	+39.41	— 7.09	+39.53	— 7.53	+39.77
Concepcion	—14.03	—53.19	—14.64	—51.72	—15.21	—50.13
Coquimbo	—12.25	—42.28	—12.72	—40.64	—13.15	—38.91
Fayal, Azores	+21.60	+70.26	+22.84	+69.69	+23.91	+69.10
Habana	— 6.35		— 6.50		— 6.56	+53.42
Honolulu						
Hongkong			— 0.69	+26.92	— 0.83	+27.63
Magdalena Bay	— 5.55		— 6.21		— 6.96	

TABLE No. 3—Continued.

Station.	1780.		1790.		1800.	
	D.	I.	D.	I.	D.	I.
	°	°	°	°	°	°
Manila	+ 0.01	+11.32	— 0.08	+12.17	— 0.18	+13.03
Montevideo			—13.71	—42.22	—13.34	—40.38
Paita						
Panama	— 7.71		— 7.87	+29.46	— 7.91	+30.22
Pernambuco		+11.26		+12.16		+12.85
Petropavlovsk	— 5.98	+63.17	— 6.02	+63.34	— 5.85	+63.51
Punta Arenas	—22.71	—66.35	—23.20	—65.71	—23.55	—64.84
Rio de Janeiro	— 6.96		— 6.62		— 6.00	
St. Helena	+14.94	—11.58	+16.39	—12.54	+17.74	—13.73
Shanghai						
Singapore						
Sydney			— 8.44	—59.73	— 8.74	—60.61
Tahiti	— 5.47	—29.71	— 5.81	—29.71	— 6.14	—29.71
Valparaiso			—14.24	—44.76	—14.61	—43.49

Station.	1810.		1820.		1830.	
	D.	I.	D.	I.	D.	I.
	°	°	°	°	°	°
Arica	—10.32	—21.31	—10.58	—19.50	—10.76	—17.77
Ascension Island	+15.39	+ 5.67	+16.72	+ 3.97	+17.93	+ 2.11
Barbados (Bridgetown)	— 2.95	+44.04	+ 2.42	+43.95	— 1.87	+43.87
Batavia	— 0.17	—30.80	— 0.56	—29.24	— 0.91	—27.99
Bombay	+ 0.90		+ 0.50		+ 0.14	
Callao	— 9.81	— 9.66	—10.14	— 8.62	—10.38	— 7.75
Cape of Good Hope	+26.67	—49.46	+27.56	—50.68	+28.29	—51.86
City of Mexico	— 7.90	+40.12	— 8.21	+40.57	+ 8.43	+41.10
Concepcion	—15.73	—48.44	—16.19	—46.71	—16.57	—44.96
Coquimbo	—13.53	—37.17	—13.85	—35.49	—14.10	—33.91
Fayal, Azores	+24.83	+68.47	+25.57	+67.83	+26.10	+67.20
Habana	— 6.52	+52.87	— 6.39	+52.42	— 6.17	+52.10
Honolulu	—11.34		—10.66		—10.13	+42.10
Hongkong	— 0.96	+28.35	— 1.04	+29.07	— 1.08	+29.75
Magdalena Bay	— 7.73		—8.49		— 9.18	+50.38
Manila	— 0.28	+13.88	— 0.38	+14.68	— 0.48	+15.41
Montevideo	—12.87	—38.64	—12.34	—37.02	—11.72	—35.50
Paita			— 9.10	+ 4.17	— 9.17	+ 4.34
Panama	— 7.81	+30.83	— 7.58	+31.33	— 7.26	+31.75
Pernambuco	+ 3.00	+13.31	+ 4.21	+13.52	+ 5.56	+13.49
Petropavlovsk	— 5.49	+63.68	— 4.95	+63.85	— 4.27	+64.01
Punta Arenas	—23.75	—63.75	—23.79	—62.49	—23.69	—61.06
Rio de Janeiro	— 5.16	—16.30	— 4.11	—14.92	— 2.87	—13.79
St. Helena	+19.00	—15.15	+20.13	—16.75	+21.14	—18.51
Shanghai						
Singapore			— 1.39		— 1.71	—12.79
Sydney	— 9.03	—61.35	— 9.26	—61.96	— 9.46	—62.42
Tahiti	— 6.46	—29.71	— 6.76	—29.71	— 7.02	—29.70
Valparaiso	—15.06	—42.15	—15.36	—40.74	—15.61	—39.31

TABLE NO. 3—Continued.

Station.	1840.		1850.		1860.	
	D.	I.	D.	I.	D.	I.
	°	°	°	°	°	°
Arica	—10.85	—16.18	—10.84	—14.77	—10.74	—13.60
Ascension Island	+19.06	+ 0.06	+20.11	— 2.09	+21.04	— 4.37
Barbados	— 1.29	+43.77	— 0.73	+43.66	— 0.21	+43.55
Batavia	— 1.20	—27.08	— 1.43	—26.58	— 1.58	—26.50
Bombay	— 0.17	+18.36	— 0.43	+18.46	— 0.62	+18.70
Callao	—10.54	— 7.03	—10.61	— 6.46	—10.58	— 6.05
Cape of Good Hope	+28.86	—52.99	+29.28	—54.04	+29.54	—55.00
City of Mexico	— 8.57	+41.67	— 8.61	+42.28	— 8.56	+42.89
Concepcion	—16.86	—43.26	—17.05	—41.63	—17.14	—40.13
Coquimbo	—14.28	—32.50	—14.37	—31.32	—14.37	—30.39
Fayal, Azores	+26.44	+66.57	+26.57	+65.97	+26.50	+65.39
Habana	— 5.87	+51.87	— 5.49	+51.76	— 5.05	+51.75
Honolulu	— 9.75	+41.39	— 9.52	+40.85	— 9.44	+40.49
Hongkong	— 1.09	+30.37	— 1.06	+30.95	— 0.99	+31.43
Magdalena Bay	— 9.77	+49.44	—10.22	+48.76	—10.50	+48.36
Manila	— 0.56	+16.06	— 0.64	+16.60	— 0.70	+17.02
Montevideo	—11.07	—34.08	—10.40	—32.78	— 9.72	—31.58
Paita	— 9.17	+ 4.53	— 9.09	+ 4.75	— 8.94	+ 4.99
Panama	— 6.86	+31.96	— 6.43	+32.09	— 6.02	+32.10
Pernambuco	+ 6.98	+13.20	+ 8.44	+12.67	+ 9.93	+11.92
Petropavlovsk	— 3.49	+64.15	— 2.66	+64.23	— 1.84	+64.38
Punta Arenas	—23.43	—59.52	—23.03	—57.89	—22.49	—56.23
Rio de Janeiro	— 1.49	—12.91	— 0.02	—12.29	+ 1.52	—11.92
St. Helena	+21.99	—20.46	+22.67	—22.52	+23.21	—24.71
Shanghai	+ 1.93	+44.47	+ 1.91	+45.24	+ 1.93	+45.79
Singapore	— 1.97	—12.73	— 2.19	—12.78	— 2.34	—12.95
Sydney	— 9.61	—62.76	— 9.70	—62.97	— 9.72	—63.04
Tahiti	— 7.24	—29.70	— 7.41	—29.70	— 7.52	—29.70
Valparaiso	—15.72	—37.89	—15.76	—36.54	—15.70	—35.27

Station.	1870.		1880.	
	D.	I.	D.	I.
	°	°	°	°
Arica	—10.54	—12.71	—10.26	—12.11
Ascension Island	+21.87	— 6.73	+22.56	— 9.16
Barbados	+ 0.27	+43.43	+ 0.66	+43.31
Batavia	— 1.65	—26.84	— 1.65	—27.60
Bombay	— 0.76	+19.08	— 0.82	+19.56
Callao	— 9.97	— 5.77	—10.26	— 5.66
Cape of Good Hope	+29.63	—55.84	+29.54	—56.56
City of Mexico	— 8.42	+43.47	— 8.18	—44.00
Concepcion	—17.13	—38.77	—17.00	—37.60
Coquimbo	—14.29	—29.78	—14.13	—29.48
Fayal, Azores	+26.22	+64.86	+25.73	+64.38
Habana	— 4.56	+51.86	— 4.03	+52.08
Honolulu	— 9.50	+40.31	— 9.71	+40.31
Hongkong	— 0.87	+31.83	— 0.72	+32.13
Magdalena Bay	—10.59	+48.22	—10.49	48.36
Manila	— 0.75	+17.29	— 0.78	+17.42
Montevideo	— 9.06	—30.50	— 8.43	—29.52
Paita	— 8.72	+ 5.26	— 8.44	+ 5.55
Panama	— 5.65	+32.03	— 5.37	+31.75
Pernambuco	+11.39	+10.95	+12.79	+ 9.83

TABLE NO. 3—Continued.

Station.	1870.		1880.	
	D.	I.	D.	I.
	°	°	°	°
Petropavlovsk	— 1.06	+64.46	— 0.39	+64.51
Punta Arenas	—21.84	—54.57	—21.09	—52.94
Rio de Janeiro	+ 3.06	—11.81	+ 4.57	—11.95
St. Helena	+23.58	—27.00	+23.79	—29.33
Shanghai	+ 1.97	+46.13	+ 2.04	+46.27
Singapore	— 2.44	—13.23	— 2.46	—13.64
Sydney	— 9.70	—62.98	— 9.62	—62.78
Tahiti	— 7.58	—29.70	— 7.58	—29.69
Valparaiso	—15.55	—34.11	—15.32	—33.10

Station.	1890.		1900.	
	D.	I.	D.	I.
	°	°		
Arica	— 9.93	—11.84	— 9.56	—11.92
Ascension Island	+23.13	—11.61	+23.55	—14.09
Barbados	+ 0.95	+43.18	+ 1.14	+43.04
Batavia	— 1.57	—28.72	— 1.41	—30.17
Bombay	— 0.82	+20.18	— 0.75	+20.91
Callao	—10.46	— 5.77	— 9.62	— 5.89
Cape of Good Hope	+29.28	—57.12	+28.86	—57.54
City of Mexico	— 7.87	+44.46	— 7.49	+44.83
Concepcion	—16.78	—36.65	—16.46	—35.93
Coquimbo	—13.89	—29.51	—13.58	—29.88
Fayal, Azores	+25.04	+63.96	+24.18	+63.60
Habana	— 3.49	+52.41	— 2.94	+52.84
Honolulu	—10.07	+40.48	—10.58	+40.83
Hongkong	— 0.54	+32.33	— 0.33	+32.41
Magdalena Bay	—10.20	+48.76	—09.74	+49.44
Manila	— 0.80	+17.40	— 0.80	+17.23
Montevideo	— 7.86	—28.64	— 7.37	—27.88
Paita	— 8.12	+ 5.86	— 7.77	+ 6.20
Panama	— 5.21	+31.39	— 5.17	+30.92
Pernambuco	+14.10	+ 8.56	+15.28	+ 7.18
Petropavlovsk	+ 0.14	+64.53	+ 0.50	+64.51
Punta Arenas	—20.27	—51.40	—19.40	—49.97
Rio de Janeiro	+ 5.98	—12.33	+ 7.28	—12.97
St. Helena	+23.80	—31.71	+23.66	—34.72
Shanghai	+ 2.15	+46.18	+ 2.28	+45.89
Singapore	— 2.42	—14.16	— 2.31	—14.81
Sydney	— 9.47	—62.45	— 9.28	—61.99
Tahiti	— 7.52	—29.69	— 7.41	—29.60
Valparaiso	—15.00	—32.25	—14.61	—31.61

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